TF 2330A

TF 2330A

Wave Analyser

INSTRUCTION MANUAL

mi
MARCONI INSTRUMENTS

Alternative Colour Coding

for Mains Leads

(Blue - Black - Green/Yellow series)

WARNING

The colour coding on mains leads is being changed to conform with international recommendations. During the change-over period, the instrument with which this manual is issued may be wired in either the old or new colours as follows:

	Old colour code	New colour code	Sleeve symbol
LINE (PHASE)	Blue	Brown	
NEUTRAL	Black	Blue	N
EARTH (GROUND)	Green/Yellow	Green/Yellow	⏚

Note particularly that BLUE is live in the old coding and neutral in the new coding.

EBA - 4
1 - 5/69

INSTRUCTION MANUAL
No. EB 2330A
for

Wave Analyser
TF 2330A

including TF 2330AR

©
1970

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

Contents

Chapter 1 GENERAL INFORMATION

1.1 Features 4
1.2 Data Summary 5

Chapter 2 OPERATION

2.1 Preliminaries 6
2.2 Calibration 8
2.3 Measurement procedures ... 9
2.4 Measurement of modulation ... 13
2.5 Signal outputs 13
2.6 Applications 13

Decibel conversion tables 18

Chapter 3 TECHNICAL DESCRIPTION

3.1 General 21
3.2 Circuit summary 23

Chapter 4 MAINTENANCE

4.1 Introduction 27
4.2 Screw fasteners 27
4.3 Removal of case 27
4.4 Access to printed circuit boards 27
4.5 A.C. mains input ranges ... 27
4.6 Performance checks 27
4.6.1 Test equipment required ... 28
4.6.2 Voltage accuracy check ... 28
4.6.3 Frequency scale accuracy check 28
4.6.4 B.F.O. frequency accuracy check 28
4.6.5 B.F.O. output check ... 29
4.6.6 Selectivity check ... 30
4.6.7 A.F.C. discriminator check 31
4.6.8 Carrier balance 32
4.6.9 Frequency response ... 32
4.6.10 Output resistance ... 32
4.6.11 Set reference 32
4.7 Cleaning rotary switches ... 32

Chapter 5 REPAIR

5.1 Introduction 33
5.2 Fault location - voltages and waveforms 33
5.3 Component location 34

Component layout illustrations ... 34

5.4 Realignment 38
5.4.1 Introduction 38
5.4.2 Test equipment required ... 38
5.4.3 Regulated power supply ... 39
5.4.4 100 kc/s I.F. Filters ... 39
5.4.5 Crystal discriminator alignment 40
5.4.6 Frequency scale alignment 41
5.4.7 B.F.O. alignment ... 41
5.4.8 Overall frequency response 41
5.4.9 Calibration signal level ... 42
5.4.10 External meter check ... 42
5.4.11 Distortion check and alignment 42
5.4.12 Residual noise and hum ... 43

Chapter 6 REPLACEABLE PARTS

Introduction and ordering 45

Chapter 7 CIRCUIT DIAGRAMS

Circuit notes 52

Fig. 7.1 Power supply 53

Fig. 7.2 Input stages 55

Fig. 7.3 I.F. and output stages ... 57

Chapter 1

General information

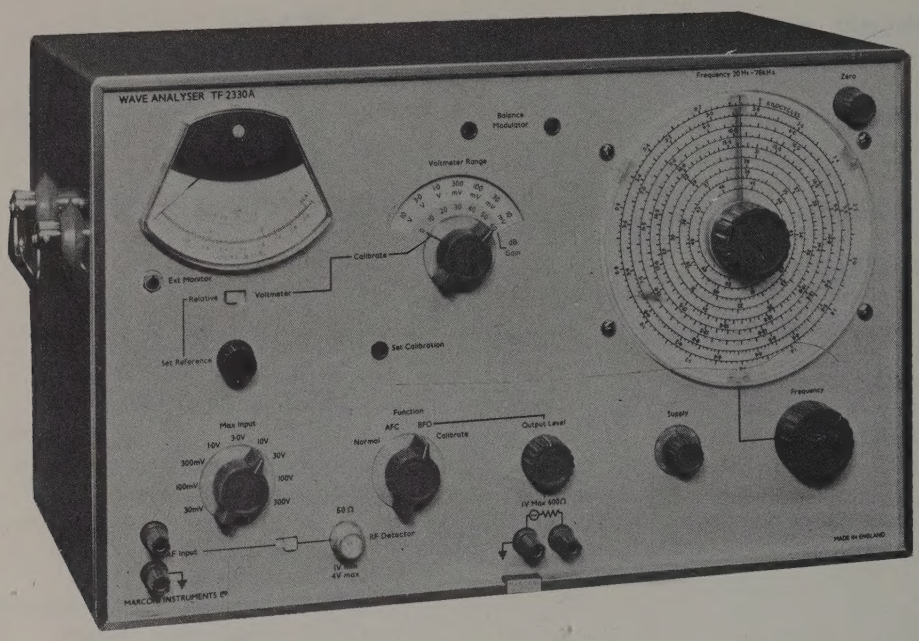


Fig. 1.1 Wave Analyser TF 2330A

1.1 FEATURES

The TF 2330A Wave Analyser provides comprehensive measurement facilities for the analysis of the performance of devices operating within the audio and ultrasonic frequency spectrum. The amplitude of each individual frequency component of a complex signal may be determined in terms of absolute voltage or relative to a fundamental datum level in decibels or in percent.

Basically the instrument comprises a sensitive narrow band tuned voltmeter covering the range 3 μV to 300 V. With a bandwidth of 7 Hz it may be tuned to any frequency from 20Hz to 76 Hz; after initial tuning internal automatic frequency control may then be employed to lock it to the signal component to obviate continual retuning, thus ensuring accurate meter readings.

Amplitude modulated r.f. signals from 100 kHz to 500 MHz may be applied via the r.f. detector for measurements of envelope distortion at any depth of modulation up to 80%.

While a signal is being investigated a variable output voltage is available, having the same frequency as the signal component to which the analyser is tuned. When the component is not harmonically connected to any other known component of the input signal, this output may be applied to an external counter for a more accurate determination of its frequency.

Another function of the instrument is to provide a convenient facility for determining frequency responses. A beat frequency oscillator, controlled by the voltmeter tuning and in step with it, provides a variable output voltage which, when set, remains constant over the whole frequency range. By applying this signal to the input of a circuit and monitoring the output with the tuned voltmeter section the response of the circuit can be rapidly ascertained.

TF 2330AR is a rack mounting model which differs only in having a special case with flanges for fitting to a 19 inch rack.

1.2 DATA SUMMARY

INPUT FREQUENCY

Working range: 20 Hz to 76 kHz. Accuracy: ±1%, ±5 Hz.

A. F. C.: Tuning remains locked to input frequency over 100 Hz drift.

AMPLITUDE RANGES

Waveform analysis

Range: Measurements down to -75 dB with respect to any fundamental level between 30 mV and 300 V. For fundamental levels below 30 mV, the measurement range is progressively reduced.

Selective voltage measurement

Range: 3 μV to 300 V in 15 ranges of 30 μV to 300 V f. s. d. in 1-3-10 sequence.

Accuracy: ±5% of full scale.

SELECTIVITY: ±3½ Hz bandwidth, at least 3 dB down, ±40 Hz bandwidth, at least 63 dB down, ±20 Hz bandwidth, at least 45 dB down, ±80 Hz and above, at least 80 dB down.

INTERNAL NOISE & DISTORTION:

Residual hum and noise, and distortion to measured signal at least 80 dB down.

INPUT RESISTANCE: 100 kΩ on maximum attenuator settings between 30 mV and 1 V:
1 MΩ on settings between 3 and 300 V.

R. F. INPUT

Frequency range: 100 kHz to 500 MHz.

Input impedance: 50 Ω type N connector.

Amplitude range: 1 V to 4 V at maximum modulation depth.

RESTORED FREQUENCY OUTPUT

Range: 20 Hz to 76 kHz.

Output: Variable up to 2.8 V p-p out of 600 Ω source, when meter reads f. s. d.

B. F. O. OUTPUT

Range: 20 Hz to 76 kHz.

Output: Variable up to 2.8 V p-p out of 600 Ω source.

Response: Flat to within ±0.1 dB over frequency range, terminated or unterminated.

RECORDER OUTPUT: 100 μA into 2.5 kΩ. Recorder input to be isolated from ground.

POWER SUPPLY: Any voltage between 190-260 V and 95-130 V a. c.; 45 to 1000 Hz; 4 VA.
OR 18-30 V d. c.; 110 mA; positive earth.

DIMENSIONS & WEIGHT:

Height	*Width*	*Depth*	*Weight*
11 in (28 cm)	18.5 in (47 cm)	11 in (28 cm)	29 lb (13.1 kg)

Accessories supplied

Shielded Adapter, type TB 39868 (Greenpar type GE 51002) for converting input or output terminals to a BNC coaxial socket.
Miniature Jack Plug, Rendar type MJP/600, for use in EXT MONITOR socket.
Mains Lead, type MIP 45001, for a. c. operation.

Chapter 2

Operation

2.1 PRELIMINARIES

In order to realize the full measurement accuracy of the wave analyser a preliminary calibration procedure is necessary. This, and the normal measurement techniques, are described in this chapter. Fig. 2.1 summarizes the functions of the controls and the measurement procedures in a form useful for subsequent quick reference.

Power Supply

The analyser may be operated from a.c. mains of a nominal 115 or 230 V, 45 to 1000 Hz; or from a d.c. supply of 18 to 30 V. For a.c. operation the stabilizer allows mains voltages of up to ±20% of the two nominal settings to be used. The instrument is normally dispatched with the 230 V setting unless specified to the contrary. In order to check or change the mains input settings see Section 4.3.

For measurements in the field, the instrument may also be d.c. powered from an external battery of from 18 to 30 V, the approximate current drain being 60 mA.

Fuses

Two fuses are fitted, one in the a.c. mains input circuit, the other in the h.t. supply to the stabilizer. The a.c. input fuses should be 50 mA rating for 230 V operation or 100 mA for 115 V. The other fuse is in circuit for both a.c. and d.c. operation and should be 160 mA rating. Both fuses are 20 x 5 mm; the a.c. input fuse a delay type, the h.t. fuse a quick-blow type.

Switching on

Before switching on:

(1) Check that the mains transformer primary connections are correct for the local supply voltage. If they have to be changed remember that the a.c. input fuse must also be changed.

(2) Set the MAINS/BATTERY slider switch on the rear panel to the position appropriate for the type of supply to be used.

(3) Connect to the power supply.

For a.c. mains use the lead supplied, fitting the small 3 pin plug to the MAINS socket at the rear of the instrument. Initially it will also be necessary to fit a suitable mains supply plug to the lead: note that the earth (or chassis) conductor has a yellow designation sleeve with a green circuit earth symbol, the neutral conductor has a black sleeve with a white 'N' and the line (or phase) conductor has no sleeve.

For d.c., connect the battery to the terminals at the rear of the instrument observing the required polarity; note that the '+' terminal is now connected to chassis. It is also advisable to disconnect the a.c. mains lead.

(4) Check and if necessary adjust the mechanical zero of the meter.

Switch on by turning the SUPPLY switch on the front panel in a clockwise direction. Allow a few minutes for the oscillator to stabilize before zeroing the frequency scale.

(1) SUPPLY switch. Turn clockwise to switch on power supply. A.C. mains or battery power supply may be used, connections and fuses at rear of instrument.

(2) FREQUENCY control. Tune to required signal frequency. Use fine control on panel to give peak meter deflection. Scale is $8\frac{1}{2}$ turn spiral calibrated 0 to 76 kHz, with zero at outer end. Read scale at position of red marker.

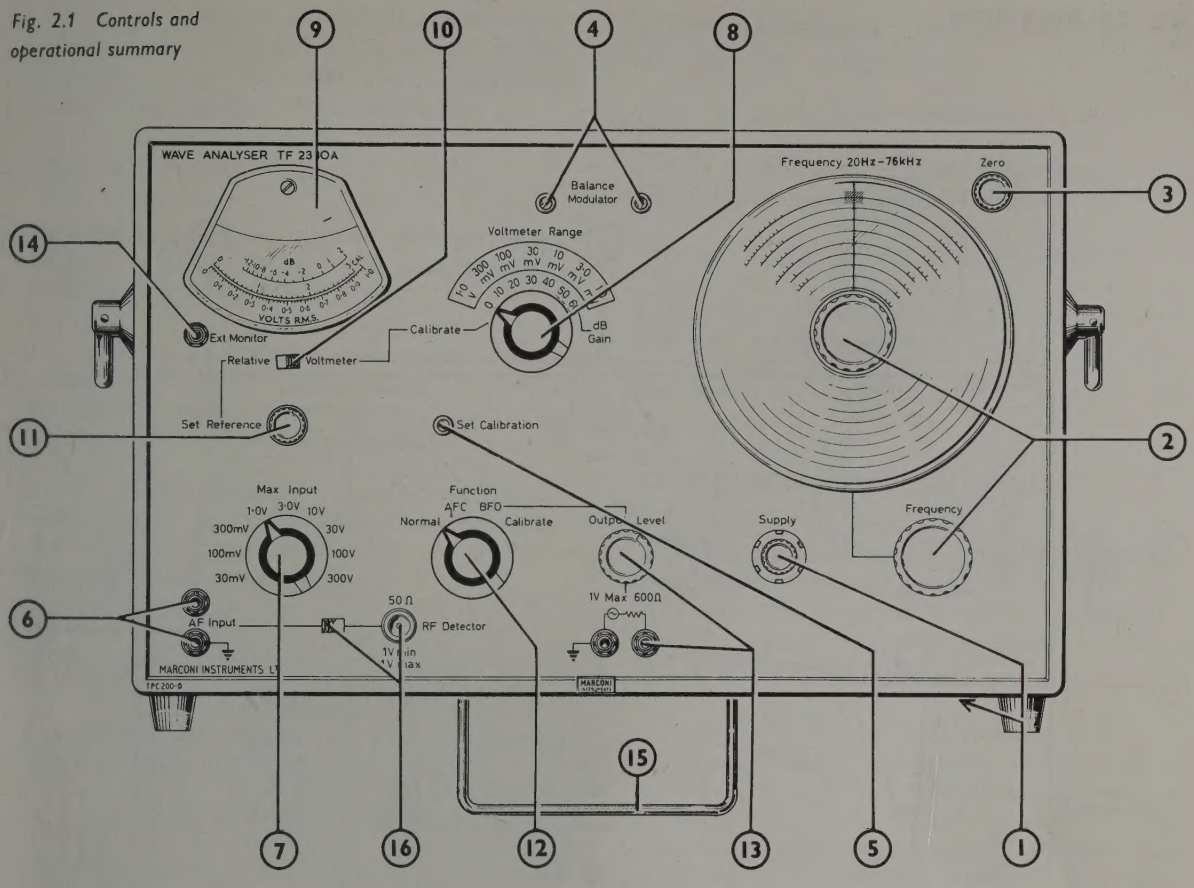
(3) ZERO control. Adjust for peak meter deflection to zero carrier with FUNCTION switch (12) at NORMAL, meter slider switch (10) at VOLTMETER, MAX INPUT switch (7) at 1 V, FREQUENCY scale at zero and no connection to input.

(4) BALANCE MODULATOR presets. Adjust both for minimum meter deflection to suppress carrier after setting carrier zero (3)

(5) SET CALIBRATION preset. Adjust to give full scale (1.0 V) to calibrate meter, with FREQUENCY scale above 20 Hz, VOLTMETER RANGE (8) and FUNCTION (12) switches set to CALIBRATE.

(6) INPUT terminals. Connect signal input 20 Hz to 76 kHz, maximum voltage 300 V (input stages protected by overload diodes).

Fig. 2.1 Controls and operational summary



Use adaptor supplied for conversion to BNC coaxial socket.

⑦ MAX INPUT switch. Use input attenuator to set highest meter range for maximum component voltage of input signal.

⑧ VOLTMETER RANGE switch. Select range to give convenient meter deflection. Overall coverage of the seven ranges is set by MAX INPUT switch ⑦

⑨ METER. For absolute voltage measurement calibrate the voltmeter ⑤ then read voltage from convenient meter scale in conjunction with position of VOLTMETER RANGE switch ⑧.

⑩ RELATIVE/VOLTMETER switch. Set for type of measurement required. RELATIVE for comparison of levels, VOLTMETER for absolute voltage measurement.

⑪ SET REFERENCE control. Level of input signal may be adjusted for relative measurements to give convenient meter deflection (0 dB or 1.0) as datum for fundamental component.

⑫ FUNCTION switch. Set to NORMAL while tuning then to A. F. C., if necessary, for measurements. Select B. F. O. for signal output at frequency shown by FREQUENCY scale setting. Set to CAL when calibrating voltmeter.

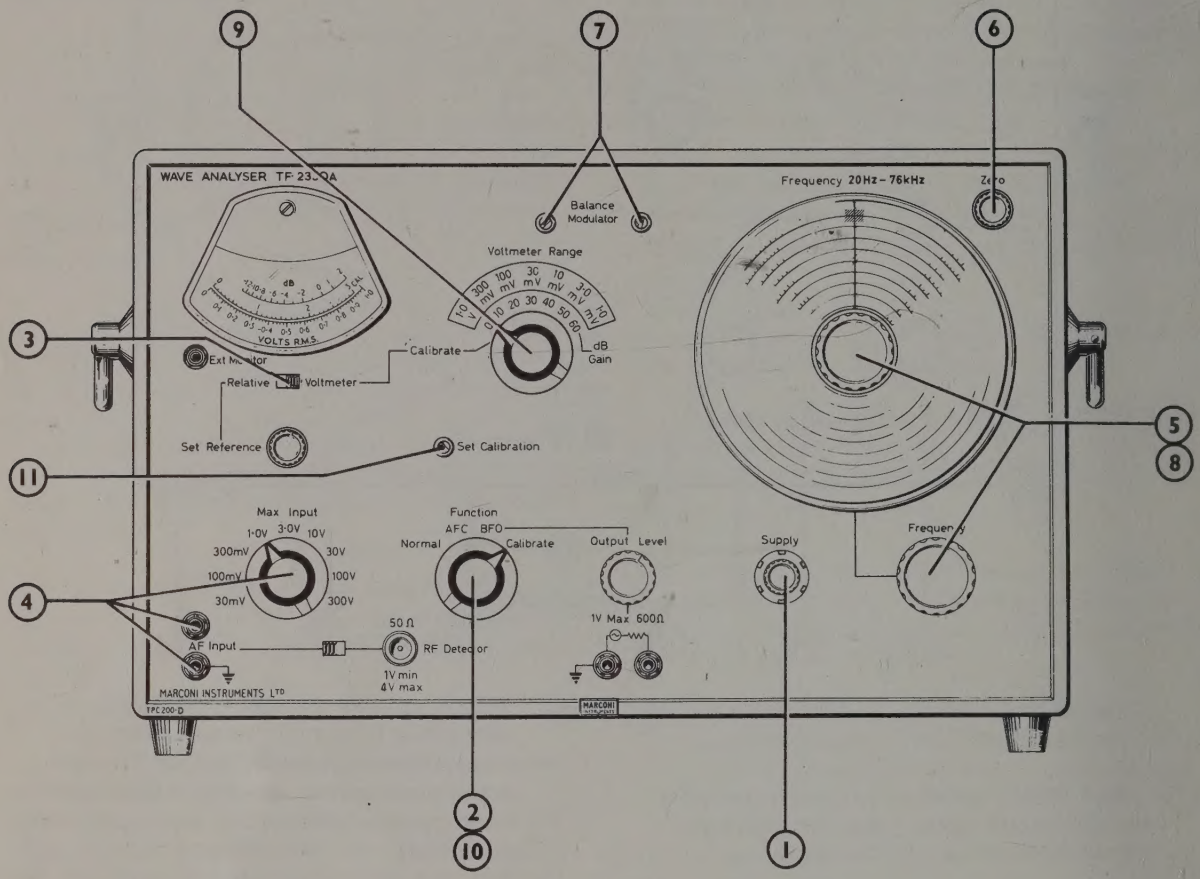
⑬ SIGNAL OUTPUT. Variable up to 1 V across 600 Ω. On NORMAL and A. F. C. positions the restored output has the same frequency as the input signal component to which the analyser is tuned. On B. F. O. position, an output of 20 Hz to 76 kHz set by FREQUENCY control, is available for use as a signal source. Use adaptor supplied to convert terminals to BNC coaxial socket.

⑭ EXT MONITOR socket. Output of 100 μA into 2.5 kΩ available for external recorder having input isolated from ground.

⑮ SUPPORT. Hinges down to raise front of instrument.

⑯ R. F. DETECTOR socket for feeding in modulated r.f. signals from 100 kHz up to 500 MHz. Switched in or out of circuit by means of the adjacent switch.

2.2 CALIBRATION



Notes

(1) During the initial calibration procedure you may notice considerable instability of the meter reading. This is only present when the FREQUENCY dial is set to zero (owing to the fact that noise in transistors is proportional to the inverse of frequency) and has no effect on actual measurements.

(2) If the instrument is used for a long period with low frequency inputs, it is advisable to occasionally check the ZERO setting so that optimum frequency accuracy is maintained.

(3) When making absolute voltage measurements over long periods it may be necessary to occasionally re-check the meter calibration to allow for slight changes in the gain of the i.f. amplifier.

Before making a measurement certain calibration procedures must be carried out. These are (a) Set carrier zero, (b) Carrier suppression (in modulator), and (c) Meter calibration.

(See Note 1 opposite)

(a) Set carrier zero - this procedure adjusts the local oscillator frequency to set up the calibration of the FREQUENCY scale.

(b) Carrier suppression - this balances the ring bridge modulator for maximum carrier suppression, the degree of suppression required depending upon the the lowest frequency to be investigated.

(c) Meter calibration - this calibrates the voltmeter at 1.0 V against an internal standard voltage and is only necessary if absolute measurements of signal voltage are to be made.

(a) Set carrier zero

(1) Switch on power supply, allow 2-3 minutes warm up before (6).

(2) Set FUNCTION switch to NORMAL.

(3) Set meter slider switch to VOLTMETER.

(4) Set MAX INPUT switch to 1.0 V or above and ensure no input connected.

(5) Set FREQUENCY scale to zero (outer end of spiral).

(6) Adjust ZERO control for maximum meter reading, using VOLTMETER RANGE switch to give convenient deflection.

(See Note 2 opposite)

(b) Carrier suppression

After having set carrier zero:

(7) Adjust BALANCE MODULATOR controls for minimum meter reading; the controls are interacting. The degree of suppression necessary depends upon the lowest subsequent measurement frequency:

For 100 Hz suppress down to 30 dB.

For 20 Hz suppress down to 40 dB.

(c) Meter calibration

(only necessary for absolute measurements).

(8) Set FREQUENCY scale above 20 Hz.

(9) Set VOLTMETER RANGE switch to CALIBRATE (fully counter-clockwise).

(10) Set FUNCTION switch to CALIBRATE.

(11) Adjust SET CALIBRATION control to give full scale deflection on meter (1.0 V).

(See Note 3 opposite)

2.3 MEASUREMENT PROCEDURES

The amplitude of the component frequencies of a complex waveform, within the range 20 Hz to 76 kHz, may be measured either in terms of absolute voltage or in decibels and percent relative to a fundamental datum level.

Prior to making a measurement it is necessary to carry out the calibration procedure given in Section 2.2. For full measurement accuracy with low level inputs also make sure that the analyser is not in a strong external magnetic hum field, especially when rack mounted.

In order to obtain consistent measurement accuracy an a.f.c. facility is included. When the analyser has been tuned to the signal under test the a.f.c. circuit will allow it to follow frequency variations of up to 100 Hz. This avoids the necessity for continual retuning when investigating a signal from a source that is prone to drift or where adjustments being made to the source tend to pull the output frequency.

Reading the meter

The instrument is calibrated in volts and decibels. Fig. 2.2 shows how the two attenuators are interconnected to give a relative measurement range of 10^4 V in an overall input range of 10^8 V. The meter has two voltage scales, 0 to 1.0 and 0 to 3, the reading being taken from the scale appropriate to the setting of the VOLTMETER RANGE switch, which provides the full scale multiplying factor. These two scales may also be used to obtain relative measurements in terms of percent, by reading the 0 to 1.0 scale as 0 to 100%, and the 0 to 3 scale as 0 to 30% after having set the meter reading for the fundamental to be 100% by means of the SET REFERENCE control.

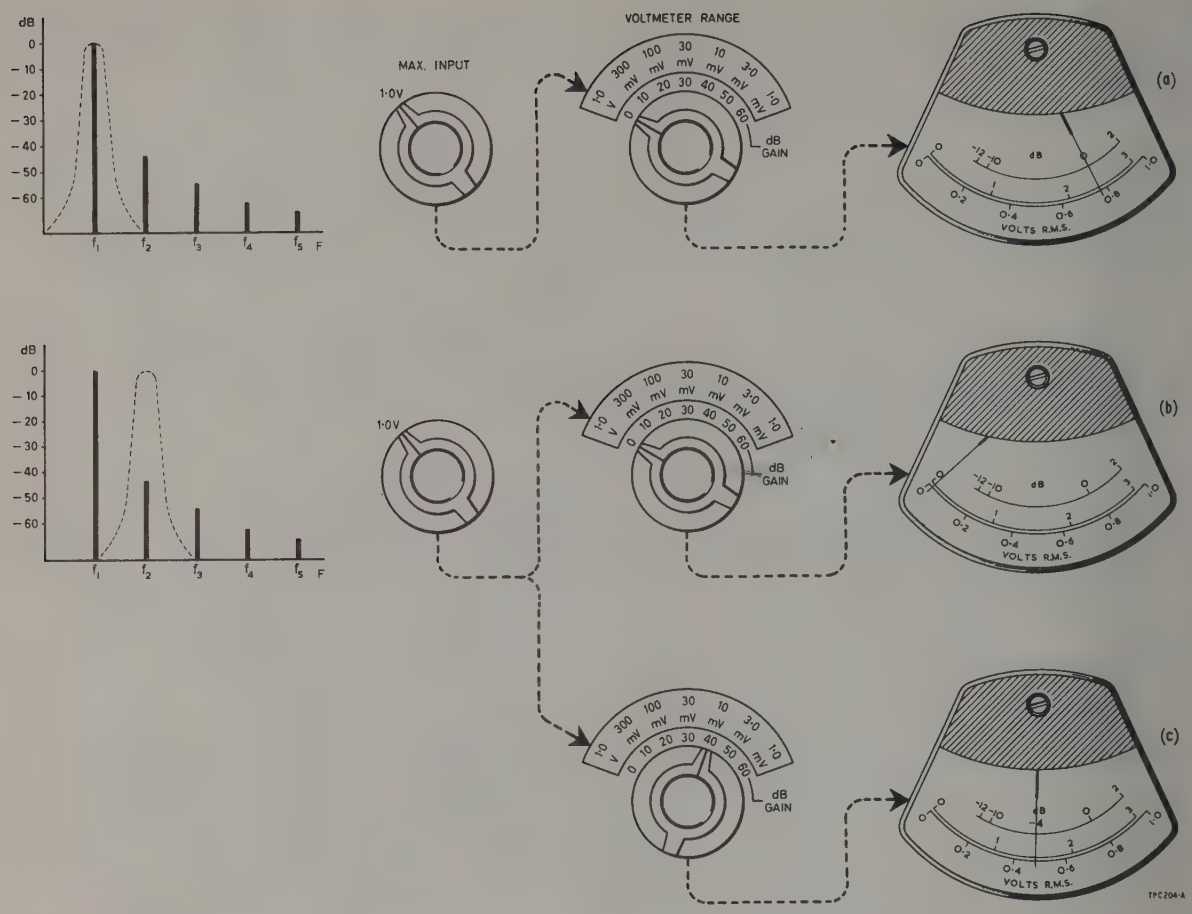


Fig. 2.2 Measurement system

Decibel calibration is in dBm, i.e. referred to 1 mW in 600 Ω, 0 dBm corresponding to 0.775 V. The meter scale covers the range -13 to +2 dB. The VOLTMETER RANGE switch, calibrated in terms of meter amplifier gain, provides a further six 10 dB steps giving a total coverage of -73 to +2 dB. To obtain a reading in dB's, subtract the VOLTMETER RANGE switch decade from the meter indication. If the fundamental amplitude has been set to 0 dB then the reading obtained will be the number of dB's the particular component is below the fundamental. The example shown in Fig. 2.2 has a second harmonic, f_2, which is 44 dB down: however, had the meter indication been f.s.d., the resultant reading would be 2-40 = -38 dB, i.e., 38 dB down.

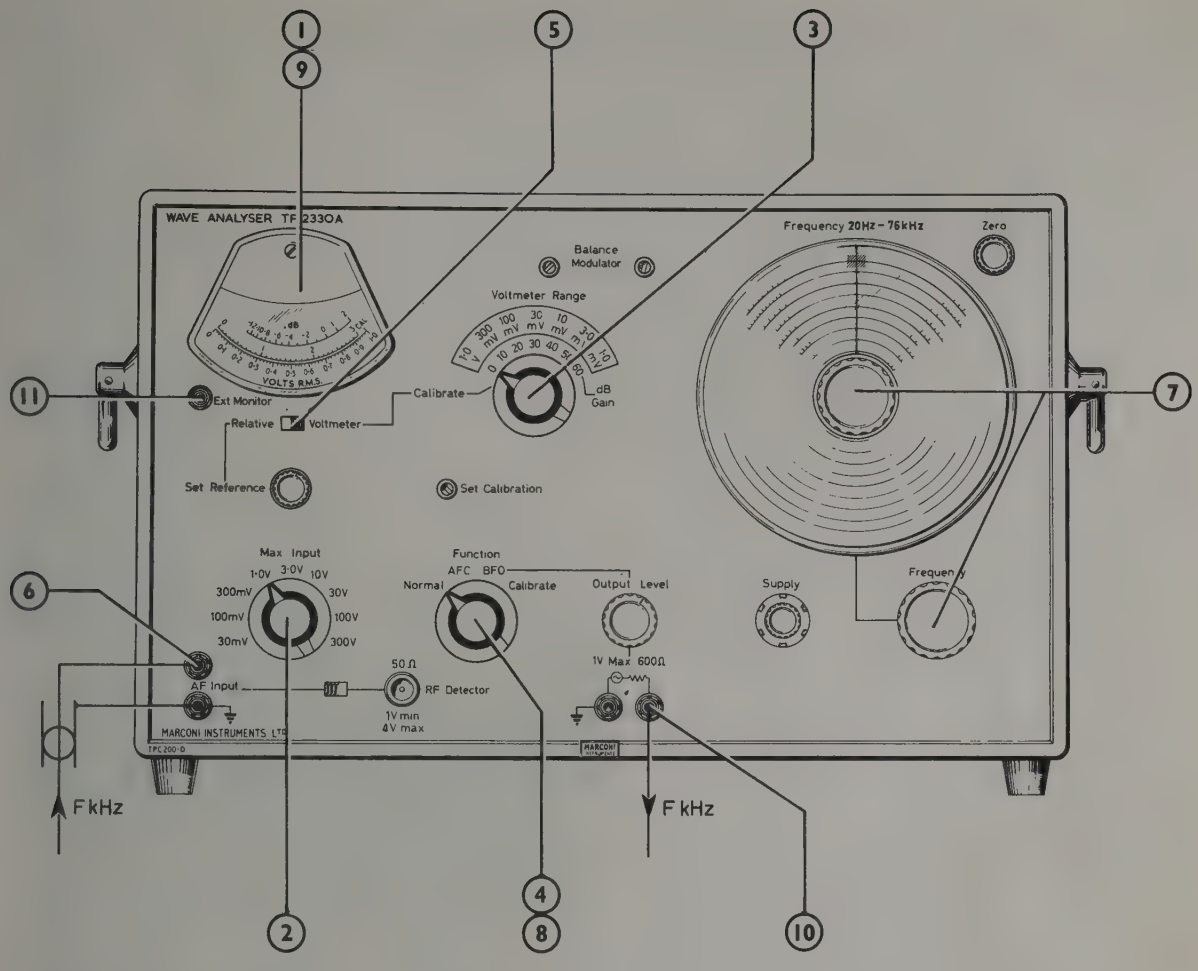
Absolute measurements

The absolute amplitude of any component of a waveform may be determined by the following procedure. The measurement may be made in volts, or in dBm where the signal is derived from a source having a terminating impedance of 600 Ω. The difference in amplitude between individual components of a waveform from any other source may be measured in dB's by algebraically subtracting the readings obtained for each component.

A harmonic analysis of a waveform can be carried out using absolute measurements though relative measurements are usually more convenient. The procedure is simplified if the signal level can be adjusted externally for setting the fundamental datum.

(1) Calibrate instrument as detailed in Section 2.2.

(2) Set MAX INPUT switch to nearest range above expected signal level or to suitably higher range if level is unknown.



(3) Set VOLTMETER RANGE switch to 0 dB (fully counter-clockwise).

(4) Set FUNCTION switch to NORMAL.

(5) Set meter slider switch to VOLTMETER.

(6) Connect signal to INPUT terminals. Use adaptor supplied for conversion to BNC coaxial socket.

(7) Tune for peak meter reading at signal component frequency. If meter deflection is below -10 dB set MAX INPUT switch to next lower range. When comparing several component amplitudes set MAX INPUT switch for highest then adjust VOLTMETER RANGE to give convenient deflection for others.

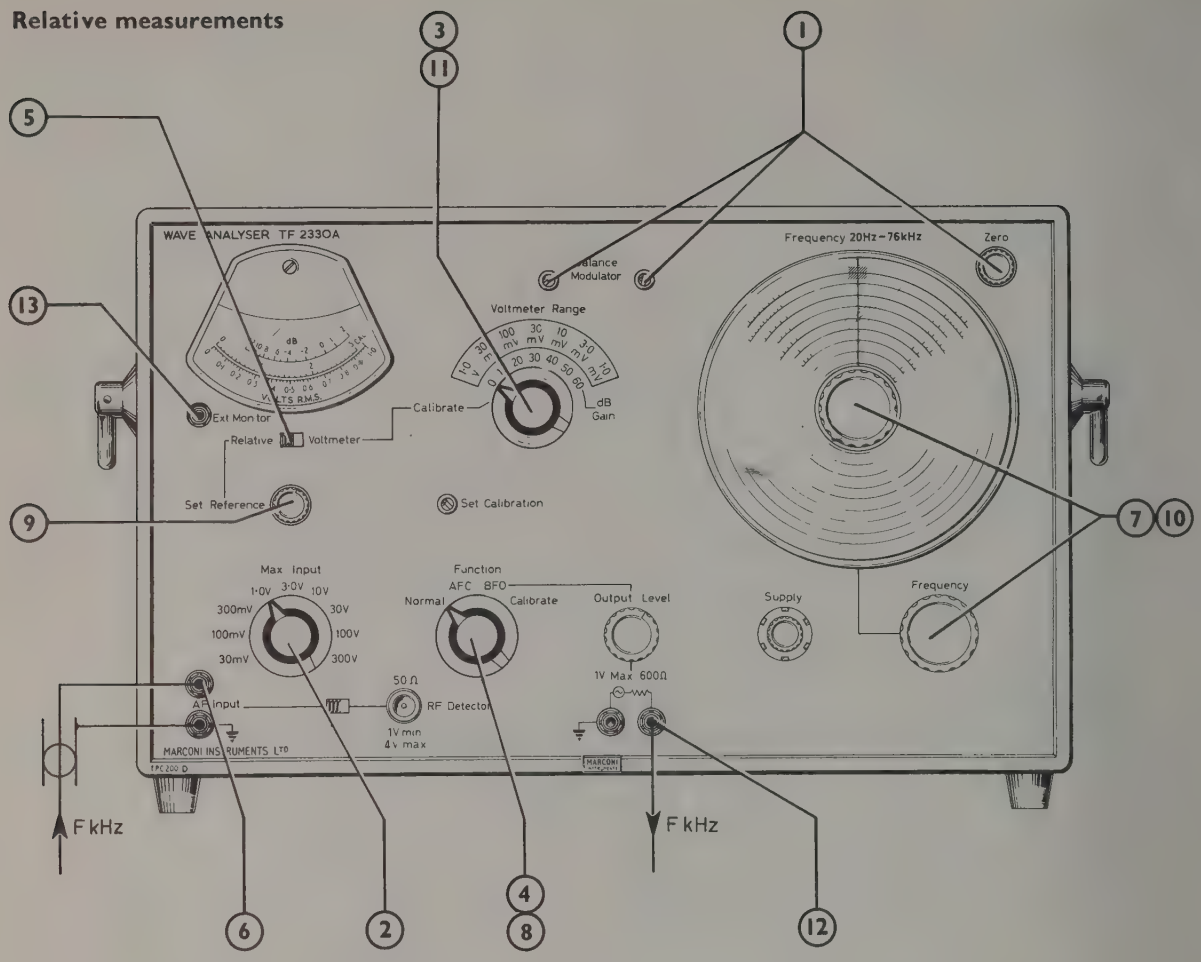
(8) Set FUNCTION switch to A. F. C.

(9) Read amplitude of signal component in conjunction with setting of VOLTMETER RANGE switch.

(10) Output of up to 1 V available at frequency of component to which analyser is tuned; see Section 2. 5.

(11) External monitor may be connected in series with meter; see Section 2. 5.

Relative measurements



An analysis of a waveform may be obtained by measuring the amplitudes of the harmonic and noise components relative to that of the fundamental frequency component. The measurements may be made in terms of decibels or percent.

For relative measurements the signal in the input amplifier may be adjusted by means of the SET REFERENCE control in order to set the fundamental component to a convenient datum level. Since all other measurements on the waveform are then made with reference to this datum it is not necessary for the voltmeter calibration to be absolute.

(1) Carry out relevant calibration procedure as detailed in Section 2.2.

(2) Set MAX INPUT switch to nearest range above expected level of fundamental or to suitably higher range if level unknown.

(3) Set VOLTMETER RANGE switch to 0 dB (fully counter-clockwise).

(4) Set FUNCTION switch to NORMAL.

(5) Set meter slider switch to RELATIVE.

(6) Connect signal to INPUT terminals.

(7) Tune initially for peak meter deflection at fundamental frequency.

(8) Set FUNCTION switch to A. F. C.

(9) Adjust SET REFERENCE control and, if necessary, MAX INPUT switch in order to set meter pointer to 0 dB or 1.0 V (100%) as required.

(10) Tune to harmonic.

(11) Adjust VOLTMETER RANGE switch to give convenient meter deflection; DO NOT ALTER MAX INPUT SWITCH SETTING. Read harmonic amplitude from meter in conjunction with setting of VOLTMETER RANGE switch.

(12) Output of up to 1 V available at frequency of component to which the analyser is tuned; see Section 2.5.

(13) External monitor may be connected in series with meter; see Section 2.5.

2.4 MEASUREMENTS OF MODULATION

The built-in r.f. detector stage can accomodate carrier frequencies within the range of 100 kHz to 500 MHz, modulation depths up to 80%, and levels between 1 V and 4 V. The input impedance at the R. F. DETECTOR socket is 50 Ω.

The procedure for measuring the harmonic content and hum level of an amplitude modulated signal is identical with that described in Section 2.3 except that, of course, the modulated signal is fed to the R. F. DETECTOR input and the adjacent switch is pressed towards the socket.

2.5 SIGNAL OUTPUTS

Two a.c. signal outputs are available at a pair of front panel terminals. The first is derived from the input waveform component to which the analyser is tuned, the second is generated internally to provide a useful signal source. Both outputs are developed across 600 Ω and are continuously variable up to 2.8 V p-p.

A d.c. output is available at the EXT MONITOR socket where an external recorder may be connected in series with the meter.

Restored frequency output

This output is so called because the 100 kHz i.f. signal derived from the input frequency component is recombined with the local oscillator output to provide a signal whose frequency is restored to that of the original input. The output voltage is highest at full scale deflection on the meter, and the waveform is sinusoidal but includes above 5% distortion.

When the analyser is being used to investigate a complex waveform having components that are not harmonically connected to any known fundamental the restored frequency output may be applied to an external frequency meter in order to ascertain the frequency of such a component with greater accuracy than is possible with the analyser. For this measurement the FUNCTION switch should be set to A. F. C. to ensure that the analyser is kept tuned to the component.

B.F.O. output

For this facility the output from a supplementary internal oscillator is combined with that of the local oscillator to provide a b.f.o. signal source tuned by and in step with the voltmeter tuning over the normal range of 20 Hz to 76 kHz. When the signal level has been set, using the OUTPUT LEVEL control, it will remain constant within 0.1 dB over the whole frequency range.

External monitor

The EXT MONITOR socket, situated adjacent to the meter, is connected in series with it. The d.c. flowing through the meter at any time may be used to energize a recorder so that a permanent record of an analysis can be made. The current for f.s.d. is 100 μA into a resistance of up to 2.5 kΩ; the recorder input must be isolated from ground and connection should be made with the jack plug provided which is a Rendar type MJP/600.

2.6 APPLICATIONS

The wave analyser is basically a highly selective and sensitive tuned voltmeter. The main application, therefore, is the measurement of individual components of a waveform whether they are harmonically related or not, for example the spurious products of modulation or noise. The ability to measure voltages as low as 3 μV, aided by the a.f.c. facility, enables a comprehensive analysis to be made of any a.f. signal.

The other main feature is the internal b.f.o. facility which may be used as a stable energizing source of a.f. either in conjunction with the tuned voltmeter section of the instrument or on its own.

Frequency spectrum

A frequency spectrum of the output signal from an audio frequency device may be obtained by slowly tuning through the frequency range of the analyser and noting the amplitude of each frequency component of the signal. If the device under investigation is generating the output itself the results will probably be required referred to a fundamental frequency. The amplitude measurements may therefore be made either in absolute or relative terms.

If the device has to be energized from an external source, such as is the case with filters and amplifiers, it is important to ensure that no harmonics are present in the input to the device.

This is necessary because phase differences between the harmonics in the input and those introduced by the device will give rise to erroneous measurements of harmonic amplitudes. Therefore, use either a low distortion source or include a low pass filter between the source and the device.

Harmonic distortion

The distortion present in a waveform may be expressed as individual harmonics, each given as a percentage of the fundamental or as a ratio in decibels. These measurements may be made in absolute or relative terms by tuning to the fundamental and then to each successive harmonic. Remember that mains supply hum components may also be of significant proportions; if so, these should be included.

An alternative way of expressing the distortion is as a total percentage distortion factor for the waveform. This may be obtained by substituting the appropriate values in one of the following expressions.

(a) The total percentage distortion is given by

$$D\% = \frac{\sqrt{(V_2^2 + V_3^2 + \ldots\ldots V_{H1}^2 + V_{H2}^2 + ..)}}{V_1} \times 100$$

where V_1 is the amplitude of the fundamental.

V_2, V_3, etc., are the amplitudes of the individual harmonic components.

V_{H1}, V_{H2}, etc., are the amplitudes of the hum components.

The values of V_1, V_2, etc., may be absolute or relative measurements in volts or decibels.

(b) When the amplitude of each distortion component is less than 10 to 15% a negligible error results from using

$$D\% = \sqrt{\frac{(V_2^2 + V_3^2 + \ldots\ldots V_{H1}^2 + V_{H2}^2 + ..)}{(V_1^2 + V_2^2 + V_3^2 \ldots V_{H1}^2 + V_{H2}^2 + ..)}} \times 100$$

This expression gives the same value for D as would normally be obtained by a distortion factor meter.

When V_2, V_{H1}, etc., are measured as percentages of the fundamental the expression simplifies to

$$D\% = \sqrt{(V_2^2 + V_3^2 + \ldots\ldots V_{H1}^2 + V_{H2}^2 + ..)}$$

(c) If the distortion components levels are measured in absolute dBm or relative dB use

$$D\% = \sqrt{\left(\frac{V_2}{V_1}\right)^2 + \left(\frac{V_3}{V_1}\right)^2 + \ldots \left(\frac{V_{H1}}{V_1}\right)^2 + \left(\frac{V_{H2}}{V_1}\right)^2 + ..} \times 100$$

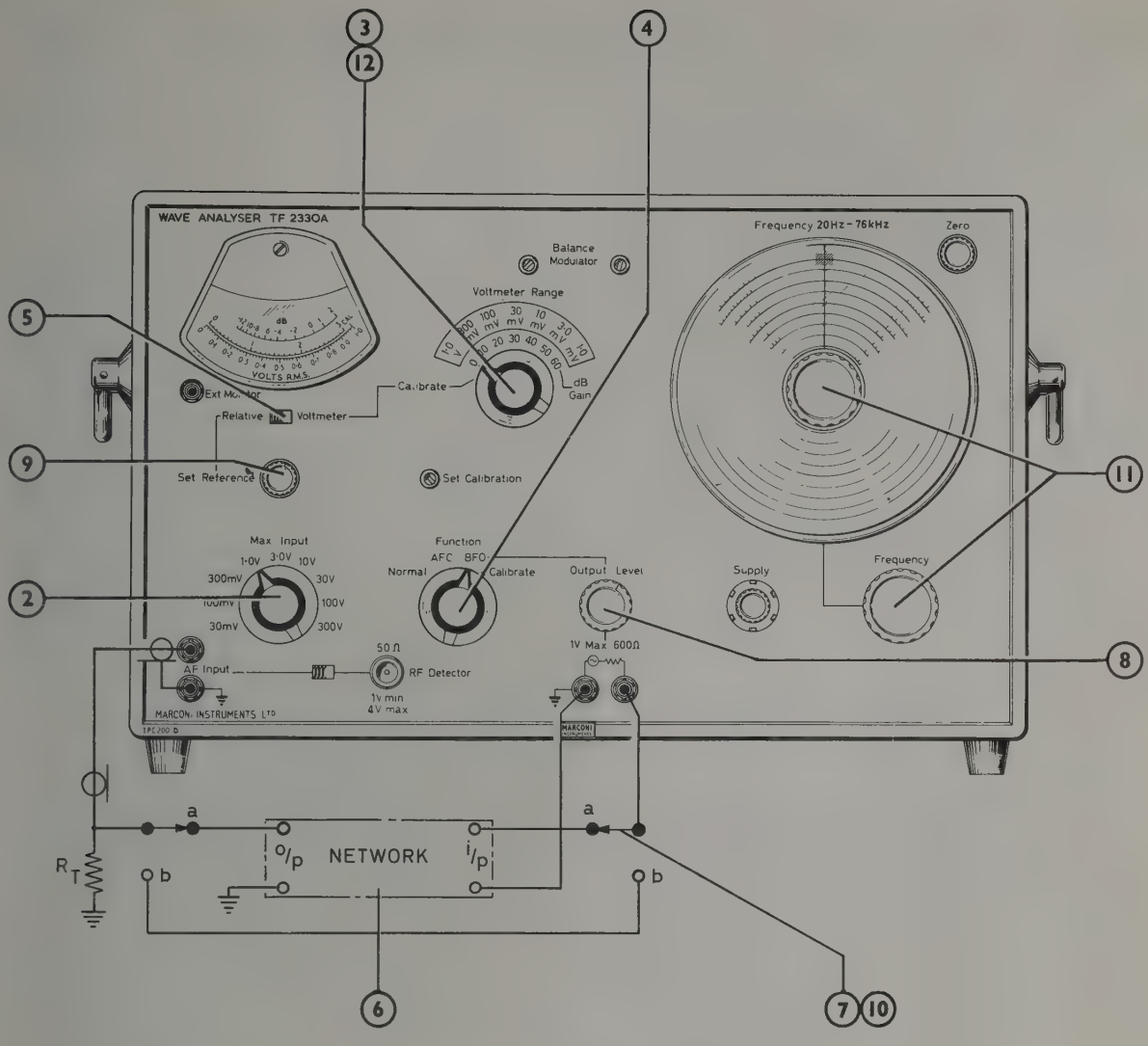
where the ratios $\frac{V_2}{V_1}$, $\frac{V_{H1}}{V_1}$, etc., are obtained from the Decibel Conversion Table at the end of this chapter, for the number of decibels each component is down on the fundamental.

Frequency response

By using the b. f. o. output as the signal source and the tuned voltmeter as the monitor, frequency responses of networks may be easily determined over the range 20 Hz to 76 kHz. Since the b. f. o. output is derived from the internal local oscillator its frequency will automatically be in step with voltmeter tuning, also its level stability is of a similar high order.

For the response of a network such as a filter, where the required measurement is the variation in output with frequency relative to a given input, a terminating resistor, R_T, must be included. It should be equal in value to the characteristic impedance of the filter so that when setting the signal datum level the circuit impedance remains the same as when the filter is connected. For the response of an amplifier the measurement will be the variation in output with frequency relative to the output as an arbitrary centre frequency so that the network switching shown will not be required. However, the amplifier should be terminated with its normal working load.

If a test voltage of considerably less than 2.8 V p-p is required connect a potential divider between the OUTPUT terminals and the network.



(1) Calibrate instrument as detailed in Section 2.2.

(2) Set MAX INPUT switch to 1.0 V.

(3) Set VOLTMETER RANGE switch to 0 dB.

(4) Set FUNCTION switch to B. F. O.

(5) Set meter slider switch to RELATIVE.

(6) Connect network under test to B. F. O. OUTPUT and INPUT terminals. Use adaptor supplied to convert terminals to BNC coaxial socket. Value of R_T should be the same as the characteristic impedance of network. Incorporate potential divider for low test voltages.

(7) Set NETWORK switch to 'b' position.

(8) Adjust OUTPUT LEVEL and SET (9) REFERENCE controls for datum signal level (0 dB or 100% on meter).

(10) Set Network switch to 'a' position.

(11) Tune FREQUENCY control over required (12) range, adjusting VOLTMETER RANGE switch to give convenient meter deflection at selected frequencies. Do not alter setting of (8) or (9).

Alternatively, when measuring frequency response of, say, an amplifier, set datum level at convenient mid-frequency (1 kHz) keeping Network switch at 'a' position.

Intermodulation distortion

Any non-linearity in an amplifier will give rise to distortion in its output. When the input to the amplifier is a simple sinewave this distortion will be in the form of harmonics and may be easily assessed by a normal harmonic analysis of the output waveform. However, when the input is a complex multi-frequency waveform certain frequency components of the waveform may interact giving rise to intermodulation distortion. Here the non-linearity causes amplitude modulation of one frequency component by another strong component. By measuring the modulation components resulting from the application of two suitable frequencies to an amplifier this distortion may be determined.

If the degree of non-linearity is uniform throughout the whole frequency range any of the distortion measurements will give equivalent results. However, if the non-linearity is worse at one or other end of the frequency range, the appropriate intermodulation distortion measurement will give a better assessment of the non-linearity than a simple harmonic analysis.

Two methods that may be used for the measurement of intermodulation distortion in an amplifier are given below, one method giving the distortion due to non-linearity at the lower end of the frequency range, the second giving that at the upper end. In each method the two test signals are applied to the amplifier under test via an adding network, which may take the form of a centre tapped transformer or a bridge configuration of resistors. This is to ensure that the two signals are not cross modulated before reaching the amplifier. To avoid overloading the input stages

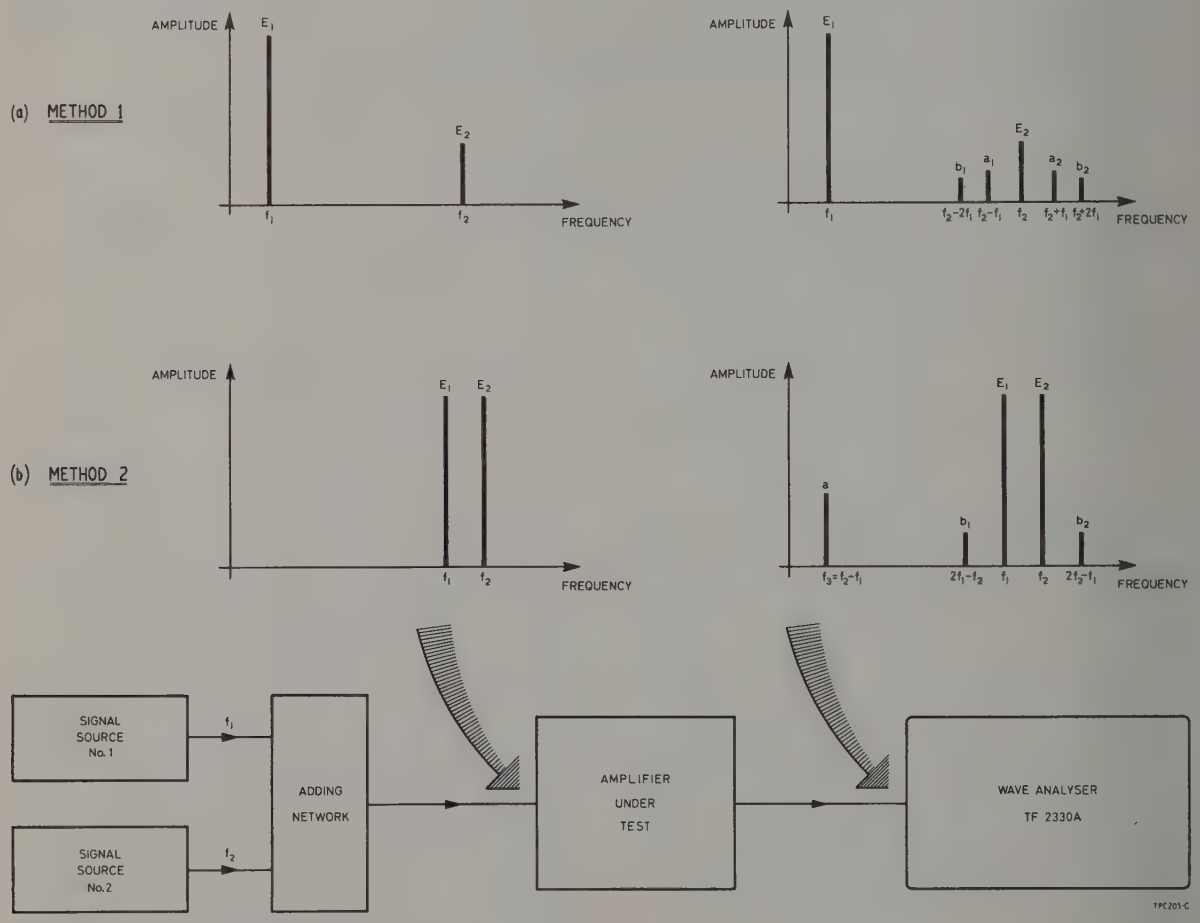


Fig. 2.3 Measurement of intermodulation distortion

the peak sum of all input signals should not exceed 1.4 x meter f. s. d.

Method 1

This method gives a measure of the distortion due to the effect of low frequencies on high frequencies, caused by non-linearity at the low frequency end.

The two test frequencies f_1 and f_2, shown in Fig. 2.3 (a), should be chosen so that f_1 and the higher modulation components come within the bandwidth of the amplifier, otherwise the falling response at the extremes of the bandwidth will attenuate the true amplitudes of these components. The amplitude of the lower frequency, E_1, should be four times that of the other, E_2. The relative amplitudes of the modulation components a_1, a_2, b_1, b_2, etc., may be measured in voltage or percent, the intermodulation distortion being given by

$$\text{I. D.\%} = \frac{\sqrt{(a_1 + a_2)^2 + (b_1 + b_2)^2 + \ldots}}{E_2} \times 100$$

or when E_2 is set as 100% this simplifies to

$$\text{I. D.\%} = \sqrt{(a_1 + a_2)^2 + (b_1 + b_2)^2 + \ldots}$$

Method 2

This method gives a measure of low frequency distortion components produced by high frequencies due to non-linearity at the high frequency end.

The two test frequencies, f_1 and f_2, shown in Fig. 2.3 (b), should be chosen so that they are near the upper end of the bandwidth while their difference frequency, f_3, is near the lower end, being between 50 and 200 Hz. The amplitudes of f_1 and f_2, E_1 and E_2 respectively, should be equal and the intermodulation distortion is given by

$$\text{I. D.\%} = \frac{a}{E_1 + E_2} \times 100$$

where a is the amplitude of f_3.

If the levels of both E_1 and E_2 are set as 50% this simplifies to

$$\text{I. D.\%} = a.$$

The above expression gives equivalent results to those that would be obtained by using the standard measurement method of filtering out the fundamental components and measuring the second order term 'a'. This method, however, neglects the third order terms b_1 and b_2 which should also be investigated.

DECIBEL CONVERSION TABLE

Ratio Down			Ratio Up	
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER
1·0	1·0	**0**	1·0	1·0
·9886	·9772	**·1**	1·012	1·023
·9772	·9550	**·2**	1·023	1·047
·9661	·9333	**·3**	1·035	1·072
·9550	·9120	**·4**	1·047	1·096
·9441	·8913	**·5**	1·059	1·122
·9333	·8710	**·6**	1·072	1·148
·9226	·8511	**·7**	1·084	1·175
·9120	·8318	**·8**	1·096	1·202
·9016	·8128	**·9**	1·109	1·230
·8913	·7943	**1·0**	1·122	1·259
·8710	·7586	**1·2**	1·148	1·318
·8511	·7244	**1·4**	1·175	1·380
·8318	·6918	**1·6**	1·202	1·445
·8128	·6607	**1·8**	1·230	1·514
·7943	·6310	**2·0**	1·259	1·585
·7762	·6026	**2·2**	1·288	1·660
·7586	·5754	**2·4**	1·318	1·738
·7413	·5495	**2·6**	1·349	1·820
·7244	·5248	**2·8**	1·380	1·905
·7079	·5012	**3·0**	1·413	1·995
·6683	·4467	**3·5**	1·496	2·239
·6310	·3981	**4·0**	1·585	2·512
·5957	·3548	**4·5**	1·679	2·818
·5623	·3162	**5·0**	1·778	3·162
·5309	·2818	**5·5**	1·884	3·548
·5012	·2512	**6**	1·995	3·981
·4467	·1995	**7**	2·239	5·012
·3981	·1585	**8**	2·512	6·310
·3548	·1259	**9**	2·818	7·943
·3162	·1000	**10**	3·162	10·000
·2818	·07943	**11**	3·548	12·59
·2512	·06310	**12**	3·981	15·85
·2239	·05012	**13**	4·467	19·95
·1995	·03981	**14**	5·012	25·12
·1778	·03162	**15**	5·623	31·62

DECIBEL CONVERSION TABLE (continued)

Ratio Down			Ratio Up	
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER
·1585	·02512	**16**	6·310	39·81
·1413	·01995	**17**	7·079	50·12
·1259	·01585	**18**	7·943	63·10
·1122	·01259	**19**	8·913	79·43
·1000	·01000	**20**	10·000	100·00
·07943	$6{\cdot}310 \times 10^{-3}$	**22**	12·59	158·5
·06310	$3{\cdot}981 \times 10^{-3}$	**24**	15·85	251·2
·05012	$2{\cdot}512 \times 10^{-3}$	**26**	19·95	398·1
·03981	$1{\cdot}585 \times 10^{-3}$	**28**	25·12	631·0
·03162	$1{\cdot}000 \times 10^{-3}$	**30**	31·62	1,000
·02512	$6{\cdot}310 \times 10^{-4}$	**32**	39·81	$1{\cdot}585 \times 10^{3}$
·01995	$3{\cdot}981 \times 10^{-4}$	**34**	50·12	$2{\cdot}512 \times 10^{3}$
·01585	$2{\cdot}512 \times 10^{-4}$	**36**	63·10	$3{\cdot}981 \times 10^{3}$
·01259	$1{\cdot}585 \times 10^{-4}$	**38**	79·43	$6{\cdot}310 \times 10^{3}$
·01000	$1{\cdot}000 \times 10^{-4}$	**40**	100·00	$1{\cdot}000 \times 10^{4}$
$7{\cdot}943 \times 10^{-3}$	$6{\cdot}310 \times 10^{-5}$	**42**	125·9	$1{\cdot}585 \times 10^{4}$
$6{\cdot}310 \times 10^{-3}$	$3{\cdot}981 \times 10^{-5}$	**44**	158·5	$2{\cdot}512 \times 10^{4}$
$5{\cdot}012 \times 10^{-3}$	$2{\cdot}512 \times 10^{-5}$	**46**	199·5	$3{\cdot}981 \times 10^{4}$
$3{\cdot}981 \times 10^{-3}$	$1{\cdot}585 \times 10^{-5}$	**48**	251·2	$6{\cdot}310 \times 10^{4}$
$3{\cdot}162 \times 10^{-3}$	$1{\cdot}000 \times 10^{-5}$	**50**	316·2	$1{\cdot}000 \times 10^{5}$
$2{\cdot}512 \times 10^{-3}$	$6{\cdot}310 \times 10^{-6}$	**52**	398·1	$1{\cdot}585 \times 10^{5}$
$1{\cdot}995 \times 10^{-3}$	$3{\cdot}981 \times 10^{-6}$	**54**	501·2	$2{\cdot}512 \times 10^{5}$
$1{\cdot}585 \times 10^{-3}$	$2{\cdot}512 \times 10^{-6}$	**56**	631·0	$3{\cdot}981 \times 10^{5}$
$1{\cdot}259 \times 10^{-3}$	$1{\cdot}585 \times 10^{-6}$	**58**	794·3	$6{\cdot}310 \times 10^{5}$
$1{\cdot}000 \times 10^{-3}$	$1{\cdot}000 \times 10^{-6}$	**60**	1,000	$1{\cdot}000 \times 10^{6}$
$5{\cdot}623 \times 10^{-4}$	$3{\cdot}162 \times 10^{-7}$	**65**	$1{\cdot}778 \times 10^{3}$	$3{\cdot}162 \times 10^{6}$
$3{\cdot}162 \times 10^{-4}$	$1{\cdot}000 \times 10^{-7}$	**70**	$3{\cdot}162 \times 10^{3}$	$1{\cdot}000 \times 10^{7}$
$1{\cdot}778 \times 10^{-4}$	$3{\cdot}162 \times 10^{-8}$	**75**	$5{\cdot}623 \times 10^{3}$	$3{\cdot}162 \times 10^{7}$
$1{\cdot}000 \times 10^{-4}$	$1{\cdot}000 \times 10^{-8}$	**80**	$1{\cdot}000 \times 10^{4}$	$1{\cdot}000 \times 10^{8}$
$5{\cdot}623 \times 10^{-5}$	$3{\cdot}162 \times 10^{-9}$	**85**	$1{\cdot}778 \times 10^{4}$	$3{\cdot}162 \times 10^{8}$
$3{\cdot}162 \times 10^{-5}$	$1{\cdot}000 \times 10^{-9}$	**90**	$3{\cdot}162 \times 10^{4}$	$1{\cdot}000 \times 10^{9}$
$1{\cdot}000 \times 10^{-5}$	$1{\cdot}000 \times 10^{-10}$	**100**	$1{\cdot}000 \times 10^{5}$	$1{\cdot}000 \times 10^{10}$
$3{\cdot}162 \times 10^{-6}$	$1{\cdot}000 \times 10^{-11}$	**110**	$3{\cdot}162 \times 10^{5}$	$1{\cdot}000 \times 10^{11}$
$1{\cdot}000 \times 10^{-6}$	$1{\cdot}000 \times 10^{-12}$	**120**	$1{\cdot}000 \times 10^{6}$	$1{\cdot}000 \times 10^{12}$
$3{\cdot}162 \times 10^{-7}$	$1{\cdot}000 \times 10^{-13}$	**130**	$3{\cdot}162 \times 10^{6}$	$1{\cdot}000 \times 10^{13}$
$1{\cdot}000 \times 10^{-7}$	$1{\cdot}000 \times 10^{-14}$	**140**	$1{\cdot}000 \times 10^{7}$	$1{\cdot}000 \times 10^{14}$

Chapter 3

Technical description

The following functional description should be read in conjunction with the circuit diagrams included at the end of this manual. Section 3.1 outlines the main electrical and mechanical features of the instrument while section 3.2 gives a more detailed account of the electrical circuits used therein.

3.1 GENERAL

This wave analyser is basically a super-heterodyne receiver covering the range 20 Hz to 76 kHz with an i.f. of 100 kHz. The input signal is fed via an attenuator (the MAX INPUT control) to an input amplifier. The signal then passes through a low pass filter to a ring bridge modulator. The filter stops any 100 kHz component in the input from reaching the i.f. amplifier stages.

The input signal is mixed with the output of a variable frequency local oscillator, range 100 to 150 kHz, in the ring bridge with a carrier rejection better than 80 dB. The difference frequency signal from the ring bridge is fed to the first part of a crystal filter having a 7 Hz pass band. This 100 kHz signal is then amplified and passed to the i.f. attenuator (the VOLTMETER RANGE control) which is an accurate ladder network having six 10 dB steps.

The output from the attenuator goes to the second part of the crystal filter and another amplifier stage. This is followed by the main i.f. amplifier which has adjustable gain, set by the SET CALIBRATION control.

The i.f. output is fed to the meter amplifier and rectifier circuit. A linear meter scale is

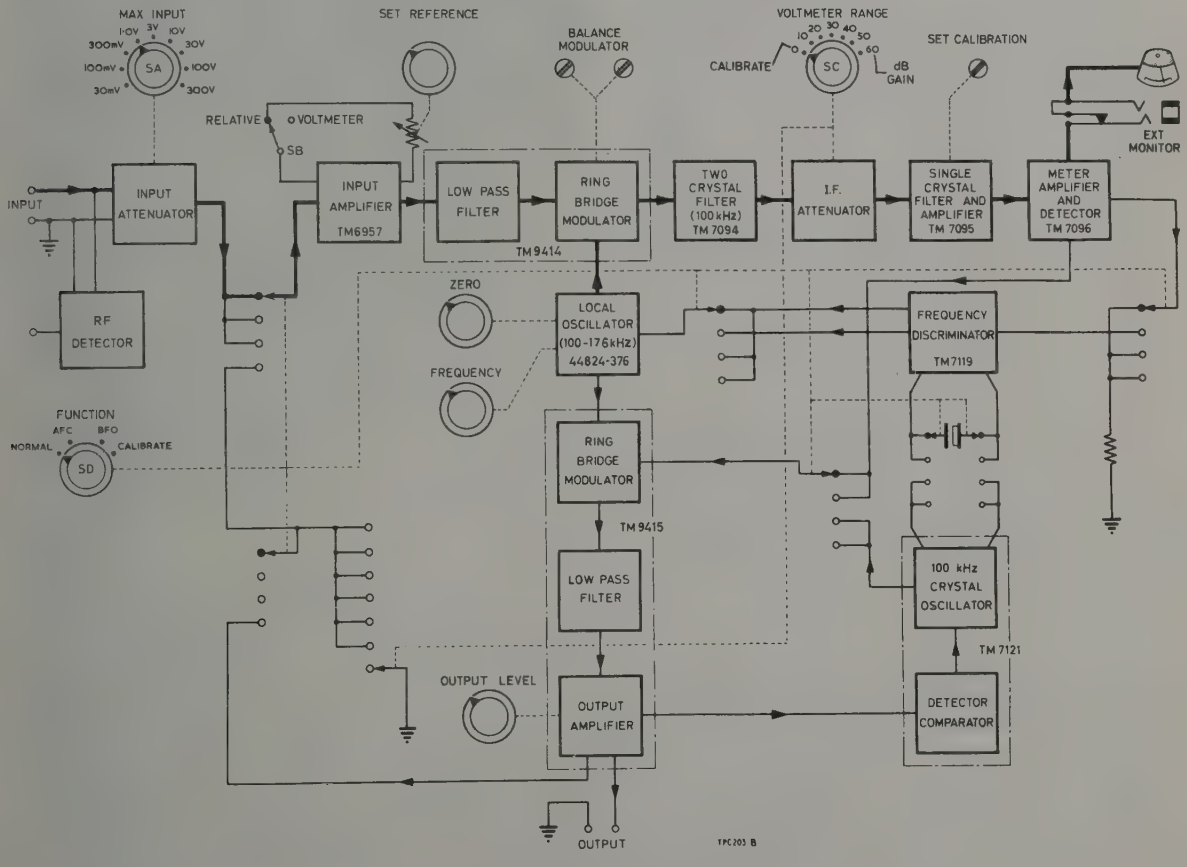


Fig. 3.1 Block diagram

obtained by having the rectifier circuit in the negative feedback loop of the amplifier. A separate output from the meter amplifier is used for a.f.c. purposes and when remixed with the local oscillator output provides the restored frequency output.

Permeability tuning is used for the local oscillator with padder and trimmer inductances in the tuned circuit to enable the frequency law to be adjusted for a precalibrated frequency scale. A crystal discriminator provides the a.f.c. signal which is applied to a voltage variable capacitor included in the tuned circuit.

Modulated r.f. signals are fed to the R. F. DETECTOR socket and then demodulated by the detector, MR49. The resulting waveform is then fed into the a.f. input line via the slider switch S.G. Fig. 3.2 gives performance curves for r.f. inputs.

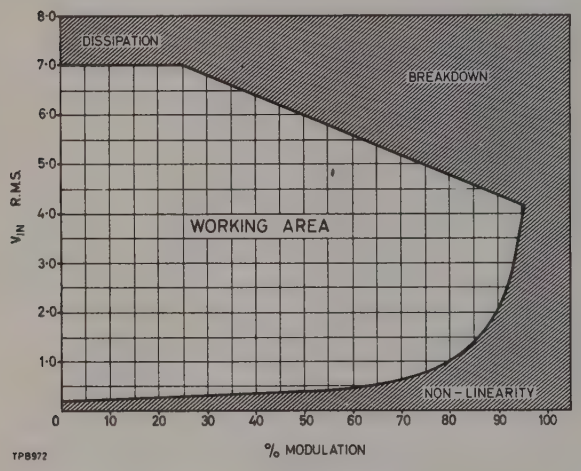


Fig. 3.2 Curve showing the working area of the r.f. detector

A restored frequency output is derived by combining the i.f. signal with the local oscillator output in another ring bridge modulator. The difference frequency, being that of the original input signal, is filtered and amplified before being fed to the output terminals via the OUTPUT LEVEL control.

A b.f.o. output is similarly derived by combining the output from a separate 100 kHz crystal oscillator with the local oscillator output. A signal taken from the output amplifier via a detector comparator provides an error signal which is added to the feedback of the 100 kHz oscillator to control its amplitude. This results in a signal of very stable output level, a feature which is utilized by also making it the calibration reference used when setting up the gain of the voltmeter section. A relay is used to switch the reference signal to the input amplifier, located remote from the high signal levels associated with the b.f.o. circuit in order to prevent 100 kHz breakthrough. The same 100 kHz crystal is used for both the discriminator and the oscillator as the two circuits are not used simultaneously.

Power for the instrument is derived from a normal series stabilizer giving an output of 15 V. When operated on a.c. mains the output from a transformer is rectified and applied to the stabilizer, the regulation of which is such that no intermediate taps are required in the transformer primary windings for the two ranges of input voltage. Similarly, it allows a wide range of battery voltage to be used for d.c. operation.

A neat mechanical layout results from the use of ten printed circuit boards for the main circuit sections. The boards are mounted on a common chassis, five above, five below, with electrostatic screens fitted between boards where necessary. Mounted on pivots to allow limited movement for servicing accessibility, the boards are retained by easily removable screws in channels riveted to each board. Although the boards have printed plug interconnections these are only used for initial testing purposes; when they are finally assembled into the instrument soldered connections are used to avoid contact troubles.

The iron dust tuning core of the local oscillator is actuated by a precision lead screw of 10 turns per inch. The required frequency range of 100 to 176 kHz is given by a movement of 0.85 in, i.e, 8.5 turns of the tuning control. The frequency scale is an 8.5 turn spiral, the appropriate part of the scale in use being indicated by a coloured marker behind the dial. 'Add up' type stops on the control mehcanism limit the lead screw travel.

In order to facilitate the determination of meter scale multiplying factor a simple mechanical computer is used to combine the functions of the two attenuators. A dial mounted on the VOLTMETER RANGE switch spindle but driven by the MAX INPUT switch is printed with the fifteen range full scale values. The dial is viewed through a window on the front panel such that only seven ranges are visible at any one time, this being the coverage of the METER RANGE switch; the selected range f.s.d. is indicated by the switch knob pointer.

3.2 CIRCUIT SUMMARY

The basic arrangement of the main circuit sections on ten printed boards also provides a convenient breakdown for the following circuit description. That section of the main circuit on any one board is shown enclosed by a broken line on the circuit diagram and each board is identified by a separate reference number.

Input Amplifier, TM 6957

The 30 mV output from the compensated input attenuator is fed to this amplifier which is a three stage feedback type having a loop voltage gain of 6. The first common emitter stage, VT50, uses a silicon p-n-p transistor for high gain with low noise and distortion. The next stage, VT51, has its base bias variable by RV51 which is set for minimum distortion. The output from this stage is fed to emitter follower VT52, with overall feedback to the emitter of VT50. Diodes MR50 and MR51 are included to protect VT50 from damage due to excessive input voltage.

For absolute measurements the overall gain is fixed, but for relative measurements a variable resistor, RV1, (the SET REFERENCE control), is switched into the emitter circuit of VT50 to give up to 10 dB of gain reduction for level setting purposes.

Low-Pass Filter and Ring Bridge Modulator, TM 9414

The low pass filter is an m-derived network having an iterative impedance of 1000 Ω. The frequency response is flat to within 0.5 dB up to 76 kHz, with attenuation at 100 kHz greater than 60 dB.

The conventional ring bridge modulator consists of MR70 to MR73, with a 1000 Ω resistor in series with each diode to swamp differences in forward resistance. The diodes are mounted on a covered B9A plug, TM 7252, thus enabling easy replacement if required, and providing a convenient point for applying a test signal for servicing purposes. Two preset potentiometers, RV2 and RV3, are mounted remote from the board on the front panel, these being the BALANCE controls which are adjusted for maximum carrier suppression.

The secondary winding of the ring bridge output transformer, T71, is tuned to 100 kHz and the output fed to the first crystal filter on TM 7094 via an emitter follower stage, VT70.

Two Crystal Filter, TM 7094

This crystal filter comprises two quartz resonators operating in the series mode and

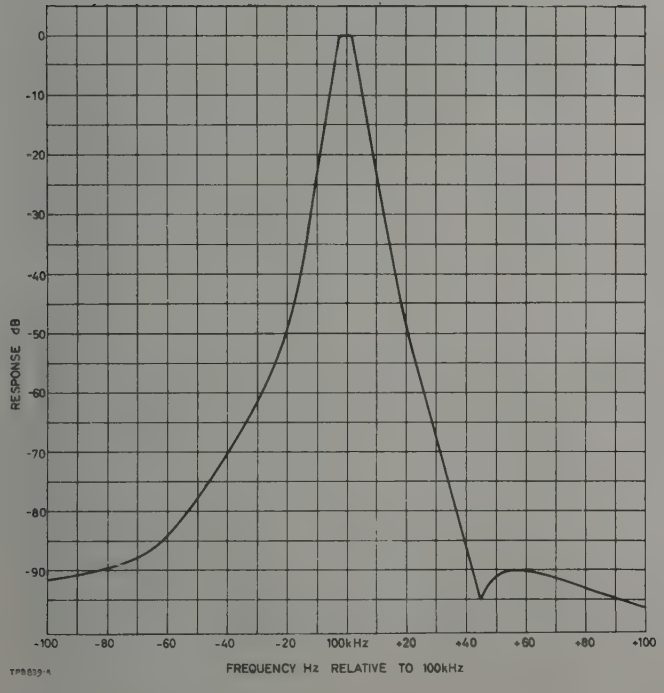


Fig. 3.3

Typical response of the crystal filters

coupled by shunt capacity. Variable resistors and capacitors connected in series with the crystals permit adjustment of Q and resonant frequency to give an overcoupled band pass characteristic. A portion of the input signal is fed past this filter section and is added to the output in such a phase as to produce nulls in the output at about 45 Hz either side of the centre frequency. This gives a double-humped response with sharp cut-off.

The filter output is fed via a common emitter stage, VT140, to the i.f. attenuator.

Single Crystal Filter and I.F. Amplifier, TM 7095

The output of the i.f. attenuator is fed to a tuned amplifier, VT160, then to a second crystal filter. This is a single quartz resonator operated in the series mode at 100 kHz. Series capacitor C165 and variable resistor RV160 are included for adjustment of resonant frequency and Q respectively. The result is a bandwidth of 7 Hz with very sharp cut-off beyond it.

The filter output is applied to a two stage feedback amplifier, VT161 and VT162, having a high input impedance and a voltage gain of approximately 150. This is followed by a further amplifier stage, VT163, which has variable gain. The SET CALIBRATION control, RV4, in the emitter circuit is used for adjusting the gain when calibrating the voltmeter.

Meter Amplifier and Rectifier, TM 7096

The meter amplifier has two stages with the meter rectifier circuit connected in the negative feedback path between the emitter of VT191 and the base of VT190. The open loop gain of the amplifier is increased by controlled positive feedback from the emitter of VT191 to the emitter of VT190. This helps to linearize the meter scale shape. Two r.f. chokes are connected in series with the meter to prevent any 100 kHz component from reaching the meter. An output, taken from the collector of VT191, is amplitude limited by diodes MR190 and MR191 and fed to the discriminator as drive for the a.f.c. circuit.

Crystal Discriminator, TM 7119

The 100 kHz input signal from the meter amplifier is amplified by VT90 and fed to the crystal discriminator. This consists of two series networks, one with a quartz resonator, the other only resistors and capacitors. The voltages across the two arms are rectified and their difference is filtered before being fed as the a.f.c. signal to the local oscillator tuned circuit.

A second output, set by RV90, is routed via the FUNCTION switch to replace the a.f.c. signal in positions other than A. F. C. The discriminator characteristic is obtained by using both the resonant and anti-resonant frequencies of the crystal; the lower frequency peak is due to the series resonance and the upper frequency null is due to the parallel resonance (anti-resonance). The series resonant frequency is adjusted by C98 and the bandwidth by C99. C97 is made adjustable in order to equalize the outputs of the two detector circuits at the centre frequency.

100 Hz Crystal Oscillator, TM 7121

This is basically two circuits: the crystal oscillator and the amplitude control circuit. The crystal, mounted remote from the board, is also used in the a.f.c. discriminator circuit.

The crystal is used in the series resonant mode in the oscillator connected between the collector of VT210 and the base of VT211, where VT210 is in a common base configuration and VT211 is an emitter follower. Capacitor C211 is used for precise adjustment of the oscillator frequency. Positive feedback is taken from the output to the emitter of VT210 via a forward biased diode MR210, the effective resistance of which is controlled by the amplitude control circuit.

The amplitude control circuit consists of a peak detector MR213 followed by a long tailed pair, VT212 and VT213, which compares the peak amplitudes with a standard direct voltage derived from a Zener diode, MR211. In order to back off the temperature effects of the detector diode a similar diode, MR212, is connected in series with the reference voltage.

Local Oscillator, 44824 - 376

The oscillator circuit comprises common emitter amplifier VT110 and an emitter follower VT111. Feedback is taken via a forward biased diode MR112 and transformer T110, the amplitude of the feedback being controlled by the d.c. flowing through the diode. The tuned circuit of the oscillator is in the collector circuit of VT110, padder and trimmer inductors L112 and L113 being included to enable the frequency law to be adjusted to fit a pre-calibrated scale. Zener diode MR111 holds the collector/base voltage of VT110 constant in order to minimize frequency drift with temperature.

The voltage variable capacitor MR110 is biased by the output of the a.f.c. discriminator to lock the oscillator frequency to the input signal under test. For positions of the FUNCTION switch other than A.F.C. the discriminator provides a fixed bias for MR110.

The output from VT111 is fed to a feedback amplifier having a class B push-pull output stage using n-p-n/p-n-p transistors VT114 and VT115. The gain of this amplifier is approximately 15. A portion of the output is rectified by MR114 and compared with the voltage at the junction of R130 and R131. The resultant error voltage is used to control the current through MR112 for amplitude control as described above.

Modulator, Low-Pass Filter and Output Amplifier, TM 9415

The b.f.o. output is obtained by mixing the output of the local oscillator with that of the 100 kHz crystal oscillator in another transformer fed ring bridge. Since carrier suppression is not critical in this case no balance adjustments are included. The difference frequency is then filtered by an m-derived filter similar to that used in the voltmeter input circuit.

The output amplifier consists of three common emitter stages in cascade with overall feedback from the emitter of VT242 to the emitter of VT240. In order to facilitate direct coupling of the stages an n-p-n transistor is used for the third stage, VT242. The output, taken from potentiometer RV5 (the OUTPUT LEVEL control) in the collector circuit of VT242, is variable up to 1 V r.m.s.; a second output, from the emitter, provides the drive for the amplitude control circuit on TM 7121.

Power Supply, TM 7116

This board consists of two sections, the rectifier and filter for the a.c. from the mains transformer and the voltage stabilizer circuit. The former is a conventional full wave rectifier using silicon diodes, MR260 and MR261. The rectified output is smoothed by a capacitor input filter comprising C260, R260 and C261.

The stabilizer input is derived either from the rectifier when operating from a.c. mains or direct from an external battery with d.c. operation. An amplifier, VT260, compares a portion of the output voltage from the series stabilizer, VT1 (mounted remote from the board), with a reference voltage derived from a Zener diode, MR262. The resultant error signal is fed via an emitter follower, VT261, to the base of the series transistor. The decoupling circuit R261 and C265 ensures that the collector supply to VT260 is free from ripple. Potentiometer RV260 is used to set up the output voltage, i.e., -15 V.

Protection for the instrument is provided by MR1, FS1 and FS2, all remote from the board. Diode MR1 prevents damage occurring due to an external d.c. supply being connected with reversed polarity. Fuse FS1 protects the a.c. mains input and FS2 protects VT1 in the event of the stabilizer output being short circuited.

Chapter 4

Maintenance

4.1 INTRODUCTION

This chapter contains information for keeping the equipment in good working order and for checking its overall performance.

Before attempting any maintenance on the wave analyser you are advised to read the preceding Technical Description chapter.

CAUTION This instrument uses semiconductor devices which, although having inherent long term reliability and mechanical ruggedness, are susceptible to damage by overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as reversal of batteries, prolonged soldering, strong r.f. fields or other forms of radiation, use of insulation testers or accidentally applied short circuits. Even the leakage current from an unearthed soldering iron could cause trouble. Before shorting or breaking any circuit, refer to the circuit diagrams to establish the effect on bias arrangements of the transistor.

4.2 SCREW FASTENERS

Screw threads used on this instrument are of the following sizes: 2BA, 4BA, 6BA, 8BA.

Cruciform headed screws are of the Phillips Pozidriv pattern; to avoid damaging them a Pozidriv screwdriver should be used.

4.3 REMOVAL OF CASE

The case assembly is retained by four 2BA Pozidriv round head screws, one at each corner of the rear panel. Undo these screws and the instrument can be slid forward out of the case; alternatively, it can be placed face downwards on a soft surface and the case lifted off.

The analyser may be adapted for mounting in a standard 19 in rack. A conversion kit for this purpose, TM 8271, is available from our Service Division and fitting instructions are supplied with it.

4.4 ACCESS TO PRINTED CIRCUIT BOARDS

The printed boards are mounted in pivot blocks and are clamped to the chassis by long screws in channels at the edges of each board. The electrostatic screening plates that are mounted between some boards are held in plastic clips and clamped in the same way as the boards.

In order to make a printed board more accessible for measurement purposes, remove the clamping screws from the board and any adjacent screens and pull out the screens; the board may then be tilted over to reveal the printed wiring. For location of printed boards, see Fig. 5.2 and Fig. 5.3.

4.5 A.C. MAINS INPUT RANGES

The mains input transformer for a.c. operation has two primary windings which are connected in parallel for the 115 V range or in series for the 230 V range. The transformer is mounted in a screening can on the underside of the chassis beneath the main tuning assembly. The primary connections of the transformer are brought out via feed-through terminals; these may be reached more easily if the chassis side plate is removed and the adjacent printed board tilted outwards. The sideplate is retained by two 4 BA screws near its upper edge.

The terminal interconnections are printed on the side of the transformer can. See Fig. 4.1.

Fig. 4.1 Mains input connections

4.6 PERFORMANCE CHECKS

The tests in this section may be used as a routine maintenance procedure to verify the main performance parameters of the instrument. All tests can be completed without removing the case, except where some internal readjustment is indicated.

4.6.1 Test equipment required

Item	Type	Minimum specification	Recommended model
a	Electronic voltmeter	Range: 0.3 V to 300 V	TF 2600
b	Frequency counter	Frequency: 20 Hz to 76 kHz	TF 2411, TF 2424A
c	L. F. oscillator	Frequency: 20 Hz to 1 kHz	TF 1101, TF 2102M

4.6.2 Voltage accuracy check

Test equipment: a

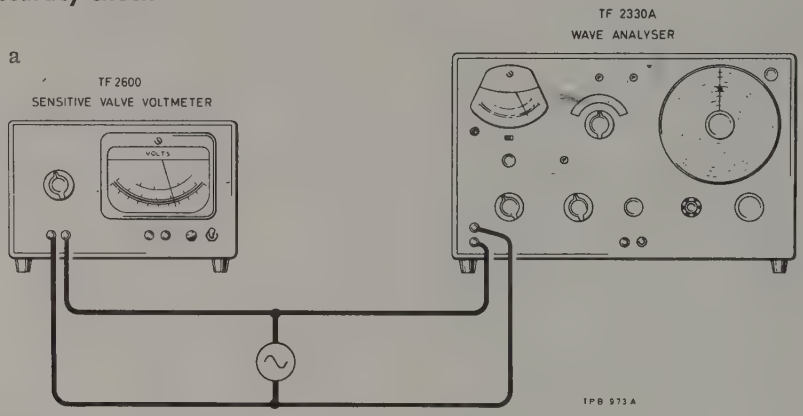


Fig. 4.2 Instruments connected for voltage accuracy check

(1) Calibrate wave analyser as in Section 2.2a.

(2) Connect known a.c. voltage supply at any convenient frequency.

(3) Monitor the a.c. voltage with an electronic voltmeter.

(4) Set FUNCTION switch to NORMAL.

(5) Set the meter slider to VOLTMETER.

(6) Set the MAX INPUT switch to obtain a reading on the meter.

The method of reading the scale on the voltmeter in conjunction with the controls is detailed in Section 2.3. With the above method a known voltage may be fed into the instrument and read off the meter. The accuracy of the reading may be checked by comparing with the reading obtained on the monitoring electronic voltmeter. It may not be possible to alter the voltage source to check the scale of the meter. In this case the MAX INPUT control can be switched in 10 dB steps to check the meter scale shape and ranges. The VOLTMETER RANGE switch may then be checked against the MAX INPUT switch for attenuation accuracy.

4.6.3 Frequency scale accuracy check

Test equipment: b and c

(1) Calibrate wave analyser as in Section 2.2a.

(2) Connect the instrument as shown.

(3) Set FUNCTION switch to NORMAL.

(4) Tune FREQUENCY to correspond with input frequency.

Procedure: The wave analyser is tuned to the frequencies provided by the A. F. oscillator between 20 Hz and 76 kHz. The frequency counter monitors the frequency and the scale setting can be compared with the counter reading at each tuning point.

The calibration should be carefully checked, at 5 kHz and 50 kHz in particular, and should be accurate to within ±1% ±5 Hz. If this figure is not met, see Section 5.4.6.

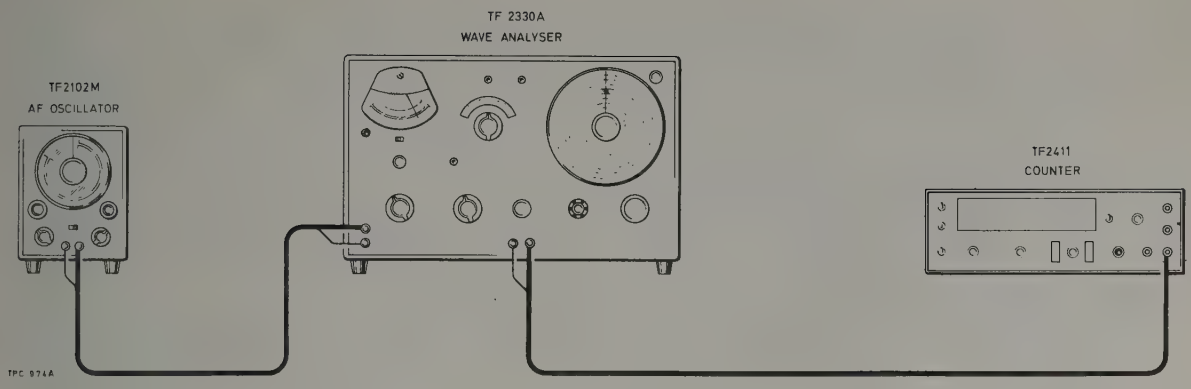


Fig. 4.3 Connections for frequency scale accuracy check

4.6.4 B.F.O. frequency accuracy check

Test equipment: b

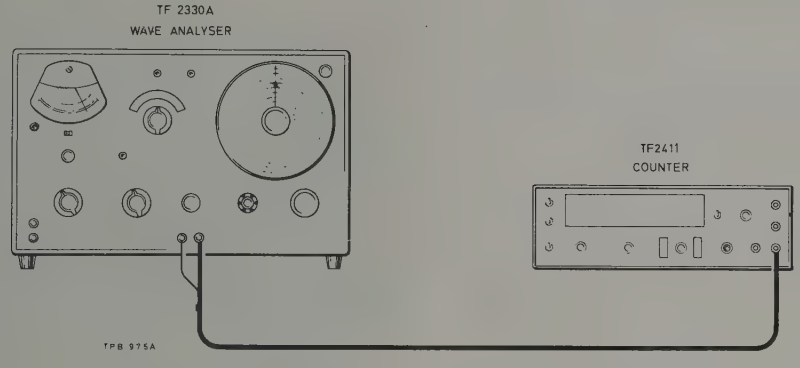


Fig. 4.4 Connections for b.f.o. frequency accuracy check

(1) Calibrate the wave analyser as in Section 2.2a.

(2) Connect the instrument as shown.

(3) Set FUNCTION switch to B. F. O.

(4) Adjust FREQUENCY between 20 Hz and 76 kHz.

Procedure: The B. F. O. frequency is now read directly on the frequency counter, via the output terminals of the wave analyser. The reading on the counter should compare with the frequency dial reading. The accuracy should be ±1% ±5Hz. If this accuracy is not met, see Section 5.4.7.

The B. F. O. frequency may be checked in conjunction with frequency scale accuracy (Section 4.6.3). With the test gear set up as in Section 4.6.3 the FUNCTION control may be switched from NORMAL to B. F. O. and the two readings should be equal on both the dial and the frequency counter. Also the output terminals may be linked to the INPUT terminals with a frequency counter monitoring the output. In this way, with the FUNCTION switch in the B. F. O. position, the frequency dial accuracy may be checked (providing the B. F. O. alignment is within claims, see Section 5.4.7.)

4.6.5 B.F.O. output check

Test equipment: a

(1) Calibrate the wave analyser as in Section 2.2a.

(2) Connect the instrument as shown.

(3) Set FUNCTION switch to B. F. O.

(4) Set the MAX INPUT switch to 1 V.

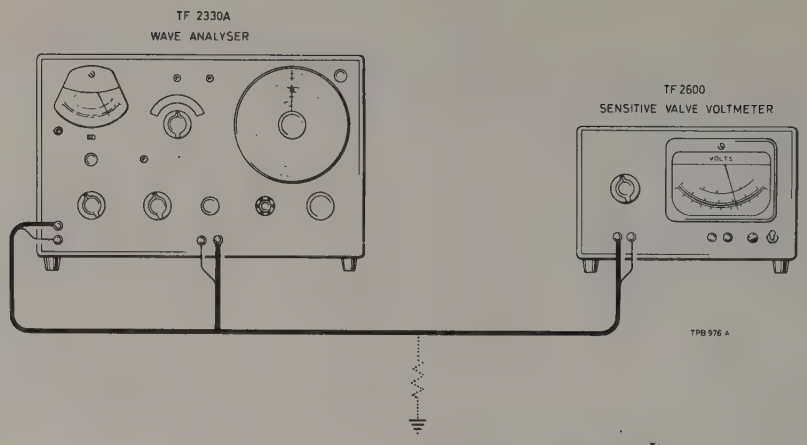


Fig. 4.5 Connections for b.f.o. output check

(5) Set the VOLTMETER RANGE switch to 1 V.

(6) Adjust OUTPUT LEVEL for f. s. d. on TF 2330 meter.

Procedure: This check may be carried out at any convenient frequency, say 1 kHz, and will reveal that the output level is within claims.

A reading will be obtained on the electronic voltmeter corresponding to the reading on the wave analyser meter. If the output is set to 1 V (f. s. d. on the meter), and terminated by 600 Ω, the output will fall to 0.5 V.

4.6.6 Selectivity check

Test equipment: b and c

(1) Calibrate wave analyser as in Section 2.2a.

(2) Connect instruments as shown.

(3) Set MAX INPUT voltage switch to 3 V.

(4) Set VOLTMETER RANGE switch to 3 V.

(5) Set FUNCTION switch to NORMAL.

(6) Set the meter slider switch to RELATIVE.

The selectivity of the 2330A band-pass filter is measured by determining the filter centre frequency, the pass band characteristics and the filter rejection characteristics. Fig. 5.8 gives the pass band response and should be consulted to clarify these checks.

A Centre frequency

Set the TF 1101 and the wave analyser to 30 Hz.

Adjust the SET REFERENCE control to give 0 dB meter reading at peak tuning.

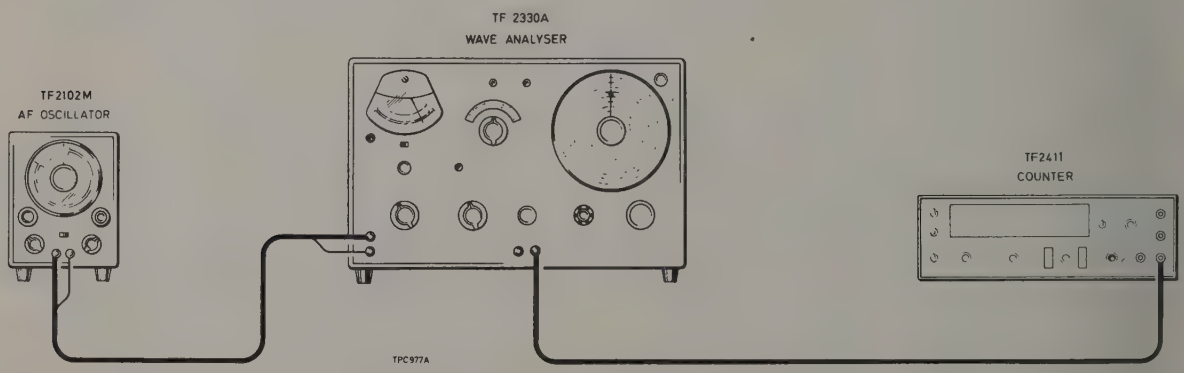


Fig. 4.6 Connections for selectivity check

Change oscillator frequency until the meter reading drops to -3 dB each side of peak tuning point. Record both frequencies, fa and fb, monitored on the frequency counter. 3 dB bandwidth should not exceed 7 Hz. Compute filter centre frequency, fc = $\frac{1}{2}$ (fa + fb).

B Pass band characteristic

Using the frequency counter as monitor, adjust the oscillator to the filter centre frequency (obtained in A).

Adjust SET REFERENCE so that the meter reads 1.0 V (f. s. d.).

Increase the oscillator frequency until the TF 2330A meter reading drops by one half of a scale division (0.99 V).

Read the counter and record the frequency (f1).

Set the oscillator back to tuning peak (centre frequency) and then decrease the frequency until the meter reading drops by one half of a scale division (0.99 V).

Record counter frequency (f_2).

NOTE: Determining these frequencies (f_1 and f_2) is critical and requires care; repeat procedures if necessary. Pass band characteristic should be such that the difference between the two 0.99 V points, $f_1 - f_2$, is greater than or equal to 3 Hz.

C Filter rejection characteristics

Set the oscillator frequency to 200 Hz and set the wave analyser to peak at 200 Hz.

Adjust the SET REFERENCE control so that the meter reads 1.0 V.

Decrease oscillator frequency to 140 Hz.

Rejection characteristics are correct if the meter reads below 0.1 mV with the VOLTMETER RANGE switch turned fully clockwise.

Increase the oscillator frequency to 260 Hz, the meter reading should again be below 0.1 mV.

NOTE: Alignment procedures are given in Section 5.4.4.

4.6.7 A.F.C. discriminator check

(1) Calibrate the wave analyser as in Section 2.2a.

(2) Connect instruments as shown.

(3) Set the MAX INPUT switch to 1 V.

(4) Set the VOLTMETER RANGE switch to 1 V.

(5) Set the FUNCTION switch to NORMAL.

(6) Set the meter slider switch to RELATIVE.

The correct operation of the a.f.c. discrimination circuit is checked by determining the frequency hold-in range.

Set the oscillator to 300 Hz; tune the wave analyser to 300 Hz.

Adjust the SET REFERENCE control for 0.1 V on the meter.

Set the FUNCTION switch to A. F. C.

Increase the oscillator frequency slowly so that the a.f.c. circuit automatically retunes and

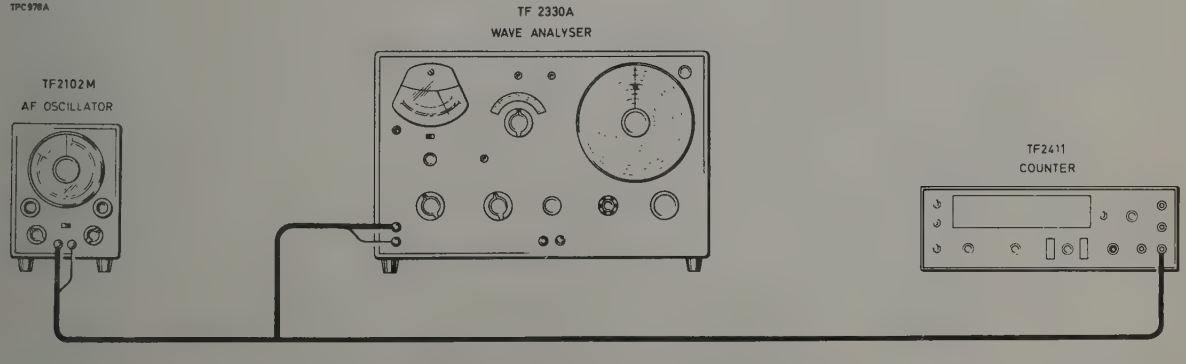


Fig. 4.7 Connections for a.f.c. discriminator check

tracks the input signal frequency. The a.f.c. circuit will eventually lose control causing a sudden drop in the meter reading. Record the counter reading at this point.

Repeat the hold-in range check by decreasing the frequency slowly, starting at 300 Hz.

Frequency hold-in range for slow input signal frequency change should be ±100 Hz minimum.

NOTE: Alignment procedure is given in Section 5.4.5.

4.6.8 Carrier balance

This check need only be carried out when the wave analyser is being used at low frequencies.

(a) Set the FUNCTION switch to NORMAL.

(b) Set the FREQUENCY dial to ZERO frequency and adjust the ZERO control for a peak on the meter.

(c) Adjust the BALANCE MODULATOR potentiometers for a minimum reading on the meter, at the same time increasing the metering sensitivity, as required, with the VOLTMETER RANGE switch.

(d) The final reading of the VOLTMETER RANGE (read off in dB) control plus the meter reading should be greater than 40 dB.

NOTE: If less than 40 dB check the Ring Bridge Modulator on board TM 9414.

4.6.9 Frequency response

(a) Connect a valve voltmeter (TF 2600A) to the B.F.O. output terminals.

(b) Tune the instrument through its frequency range from 20 Hz to 76 kHz and check the frequency response in both the terminated and unterminated conditions. The frequency response should be flat to within ±0.1 dB over the entire range.

4.6.10 Output resistance

For this check a suitable calibrated variable resistor is required, e.g. 1 Ω to 1 kΩ.

(a) Set the FUNCTION switch to B.F.O.

(b) Connect the B.F.O. output to the input terminals and adjust the OUTPUT LEVEL control for f.s.d. on the meter.

(c) Connect the variable resistor in parallel with the B.F.O. output terminals and adjust the resistor so that the meter reads half full scale. The resistance value should then be 600 Ω ±25%.

4.6.11 Set reference

(a) Set the FUNCTION switch to B.F.O.

(b) Set the VOLTMETER/RELATIVE switch to RELATIVE.

(c) Turn the SET REFERENCE control fully clockwise.

(d) Connect the B.F.O. output terminals to the INPUT terminals and, using the range switches and OUTPUT LEVEL control, obtain an f.s.d. reading on the meter.

(e) Turn the SET REFERENCE control fully counter clockwise and the meter should fall by at least 10 dB.

4.7 CLEANING ROTARY SWITCHES

If it is necessary to clean the contact of any rotary switches, this should be done with benzine or white spirit (not carbon tetrachloride), and the contacts should afterwards be wiped with a suitable lubricant such as a 1% solution of petroleum jelly in white spirit. Avoid lubricants containing soap or solid materials.

The chain drive from the MAX INPUT control to the VOLTMETER RANGE control may be lubricated with the above solution of petroleum jelly.

Chapter 5

Repair

5.1 INTRODUCTION

This chapter is intended to help operators or users to fault-find, carry out internal checks, make minor adjustments and re-align circuits; use in conjunction with the circuit diagrams at the rear of this manual. Performance limits quoted are for guidance only and should not be taken as guaranteed performance specifications unless they are also quoted in the Data Summary section. Details of case removal and access to printed boards are explained in Chapter 4.

CAUTION See Section 4.1 for precautions in handling semiconductors and for advice on screw fasteners.

In case of any difficulty, please write or phone the Marconi Instruments Service Division (see address on back cover) or nearest representative, quoting the type and serial number on the data plate at the rear of the instrument. If the instrument is being returned for repair, please indicate clearly the nature of the fault or the work you require to be done.

5.2 FAULT LOCATION—VOLTAGES AND WAVEFORMS

As an aid to fault location, a functional check can be made by observing waveforms and static voltages. To do this connect the B. F. O. output to the INPUT terminals and set the controls as follows:

FUNCTION switch to B. F. O.

Meter slider switch to VOLTMETER

MAX INPUT to 1 V.

VOLTMETER RANGE to 1 V.

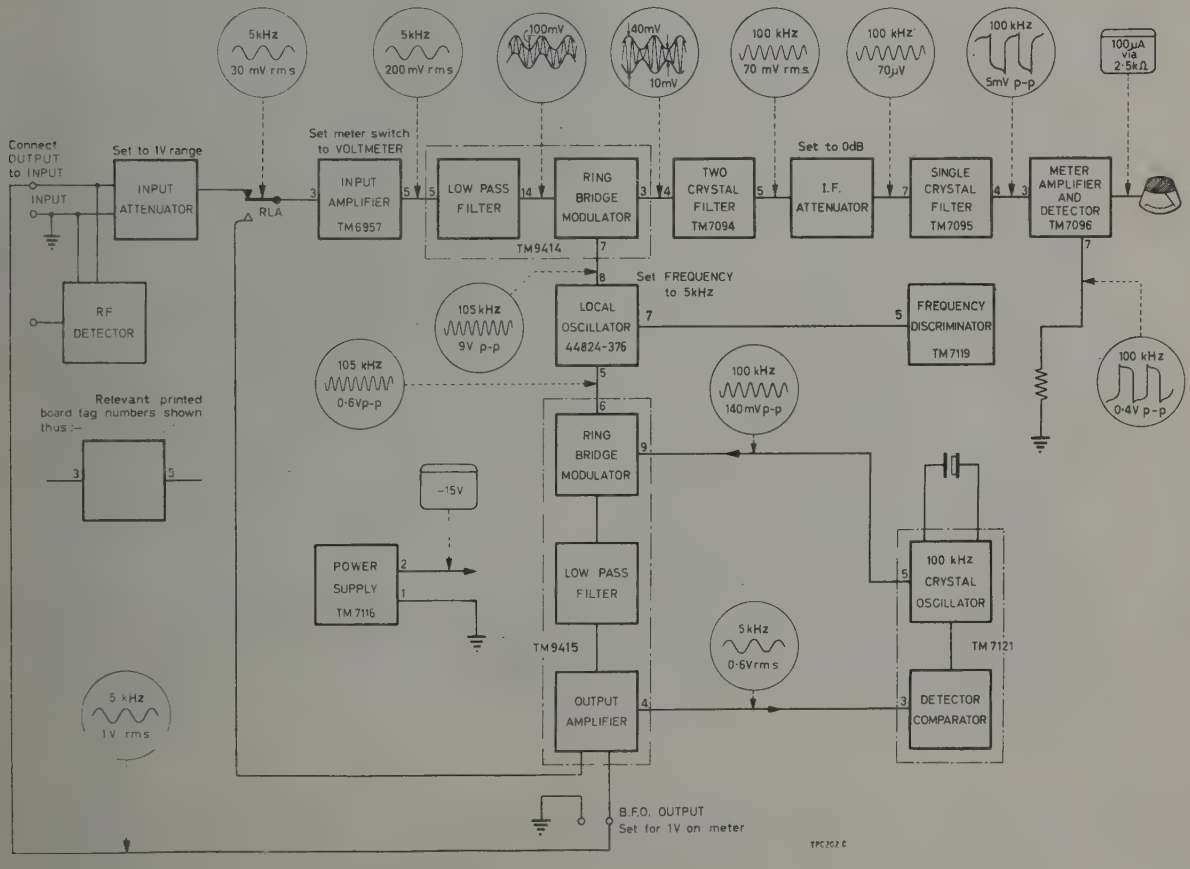


Fig. 5.1 Functional check

FREQUENCY to 5 kHz.

OUTPUT LEVEL to give f. s. d. on the meter.

Using an oscilloscope of at least 5 MHz bandwidth and 20 mV/cm sensitivity, such as Marconi Instruments type TF 2210, 2200 or 2201, check that the stage output waveforms are similar to those in Fig. 5.1.

Measure the static voltages to chassis using a d. c. voltmeter of 20 kΩ/V, such as an Avometer model 8. Typical values are shown on the circuit diagrams.

5.3 COMPONENT LOCATION

The following photographs give clear indication of all printed board circuits, presets and components:

Fig. 5.2 Top of the instrument with case removed.

Fig. 5.3 Bottom of the instrument with screening cover removed.

Fig. 5.4a VOLTMETER RANGE switch, SC.

Fig. 5.4b MAX INPUT switch, SA.

Fig. 5.5 R. F. detector unit.

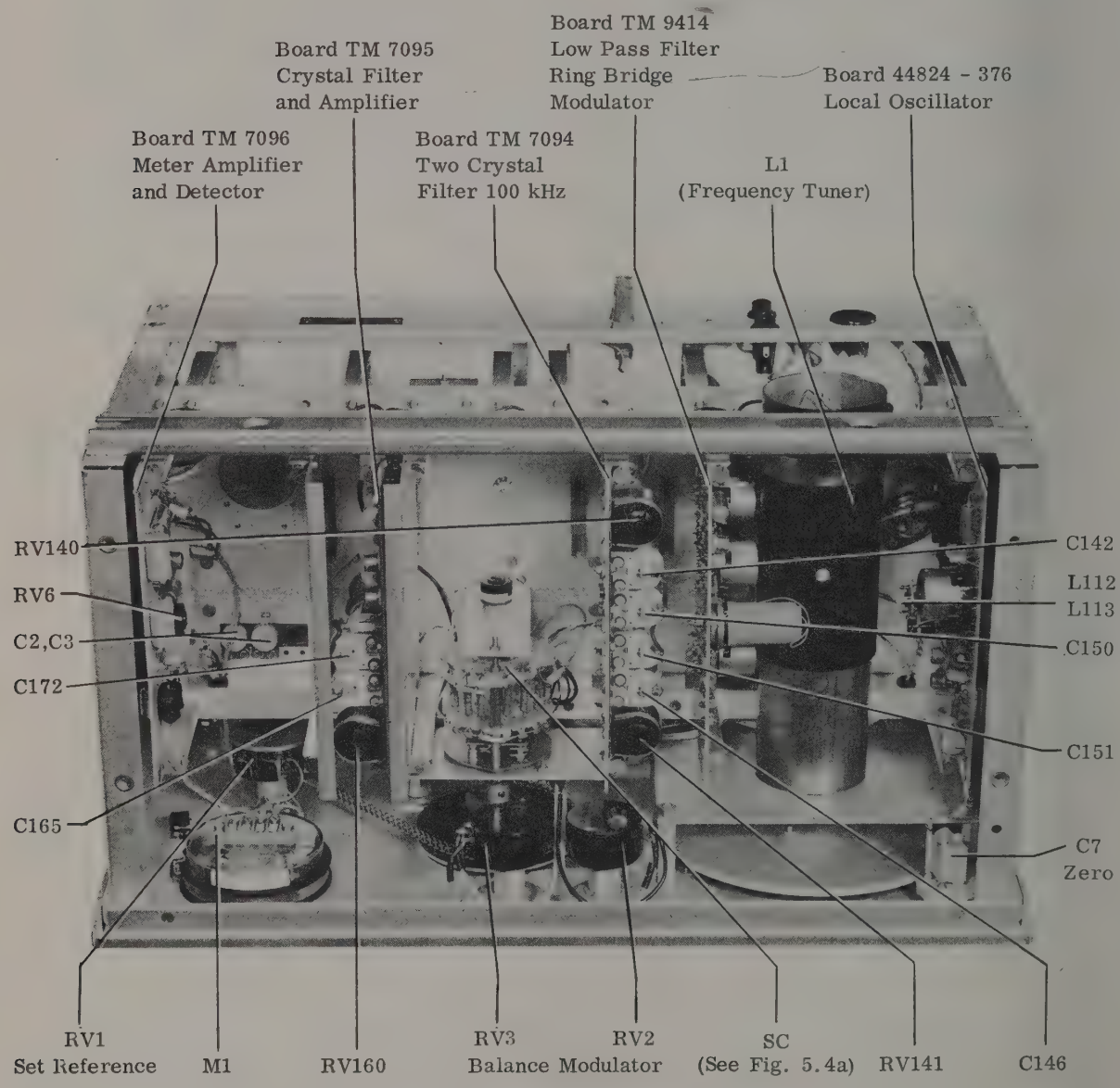


Fig. 5.2 Top of the instrument with case removed

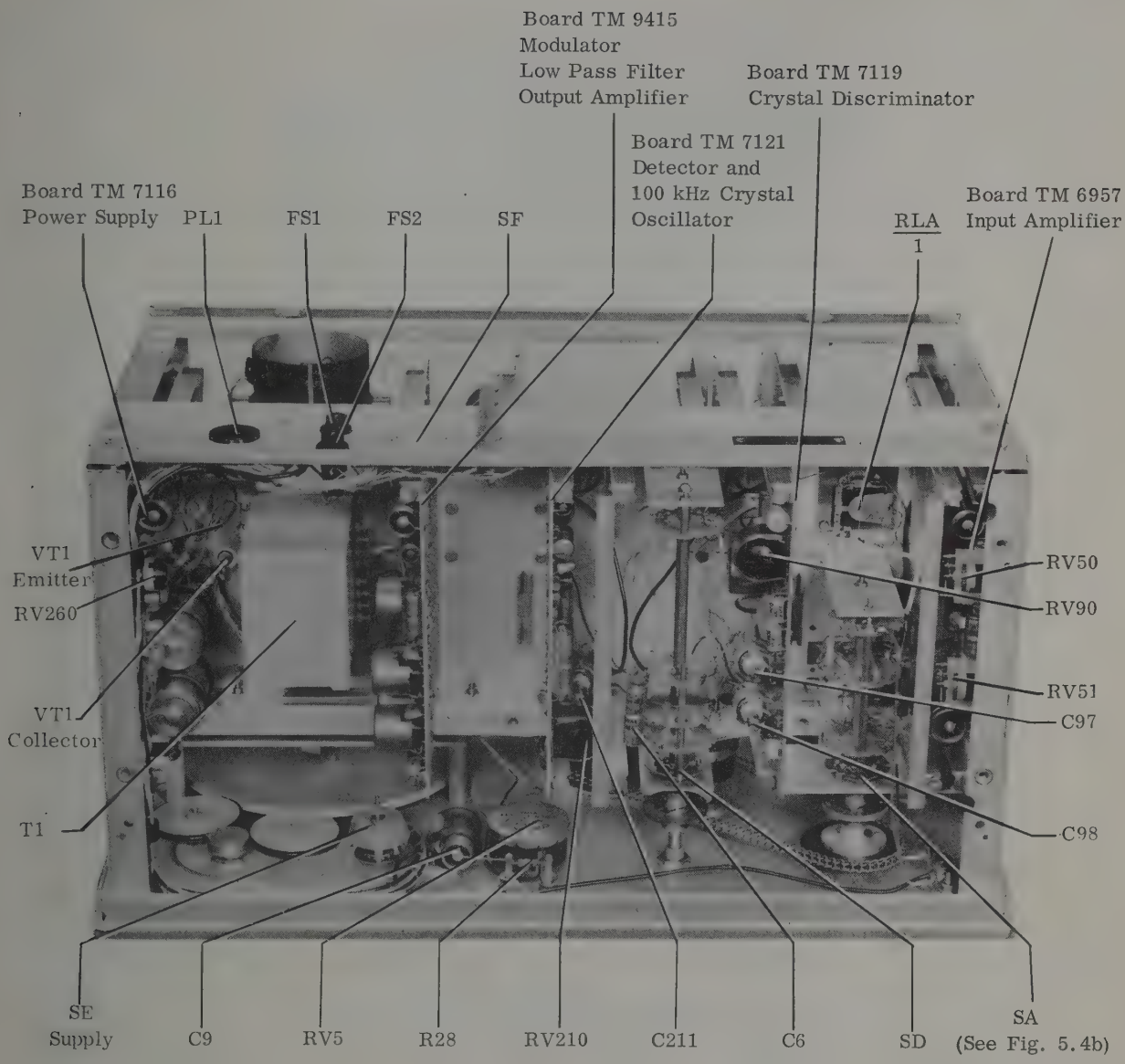


Fig. 5.3 Bottom of the instrument with screening cover removed

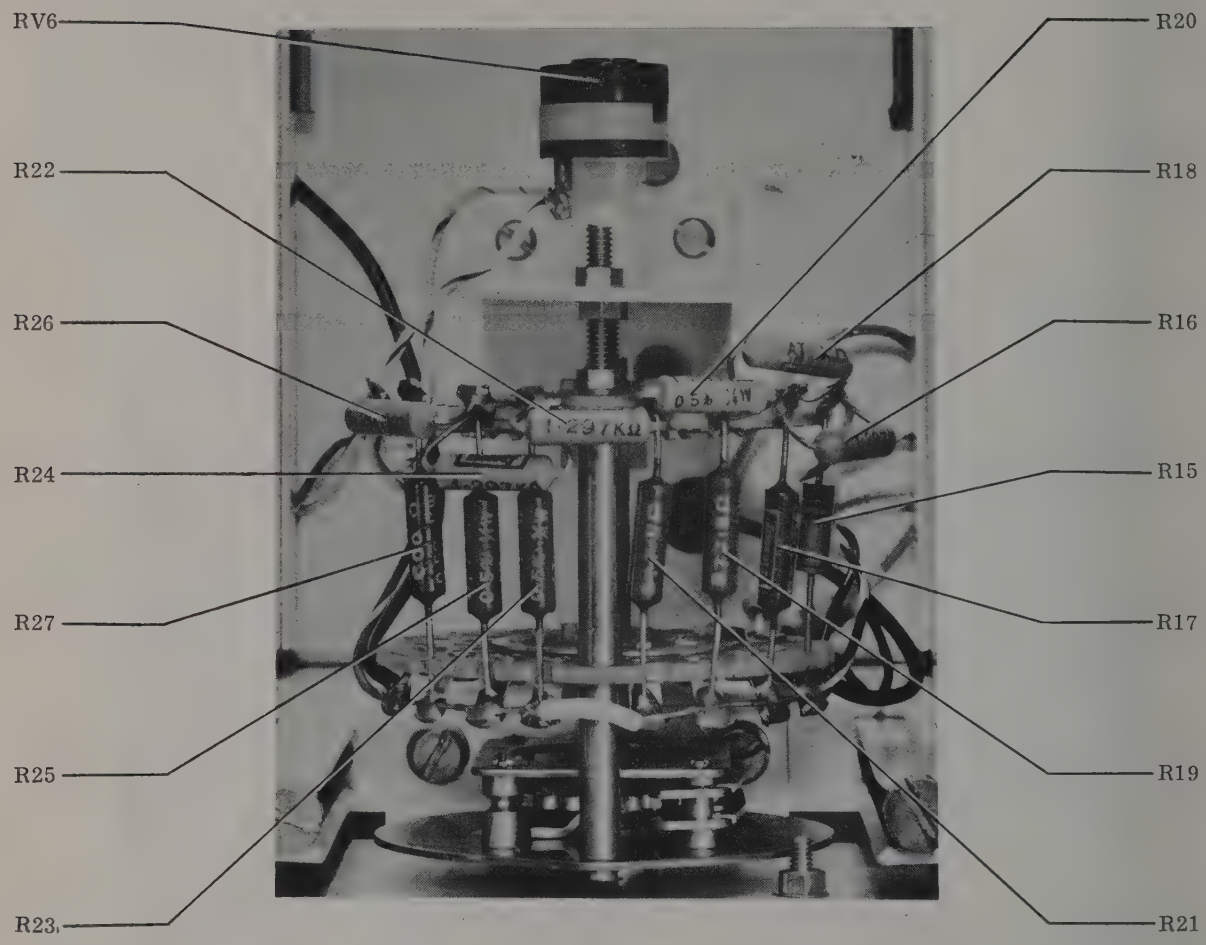


Fig. 5.4a VOLTMETER RANGE switch, SC

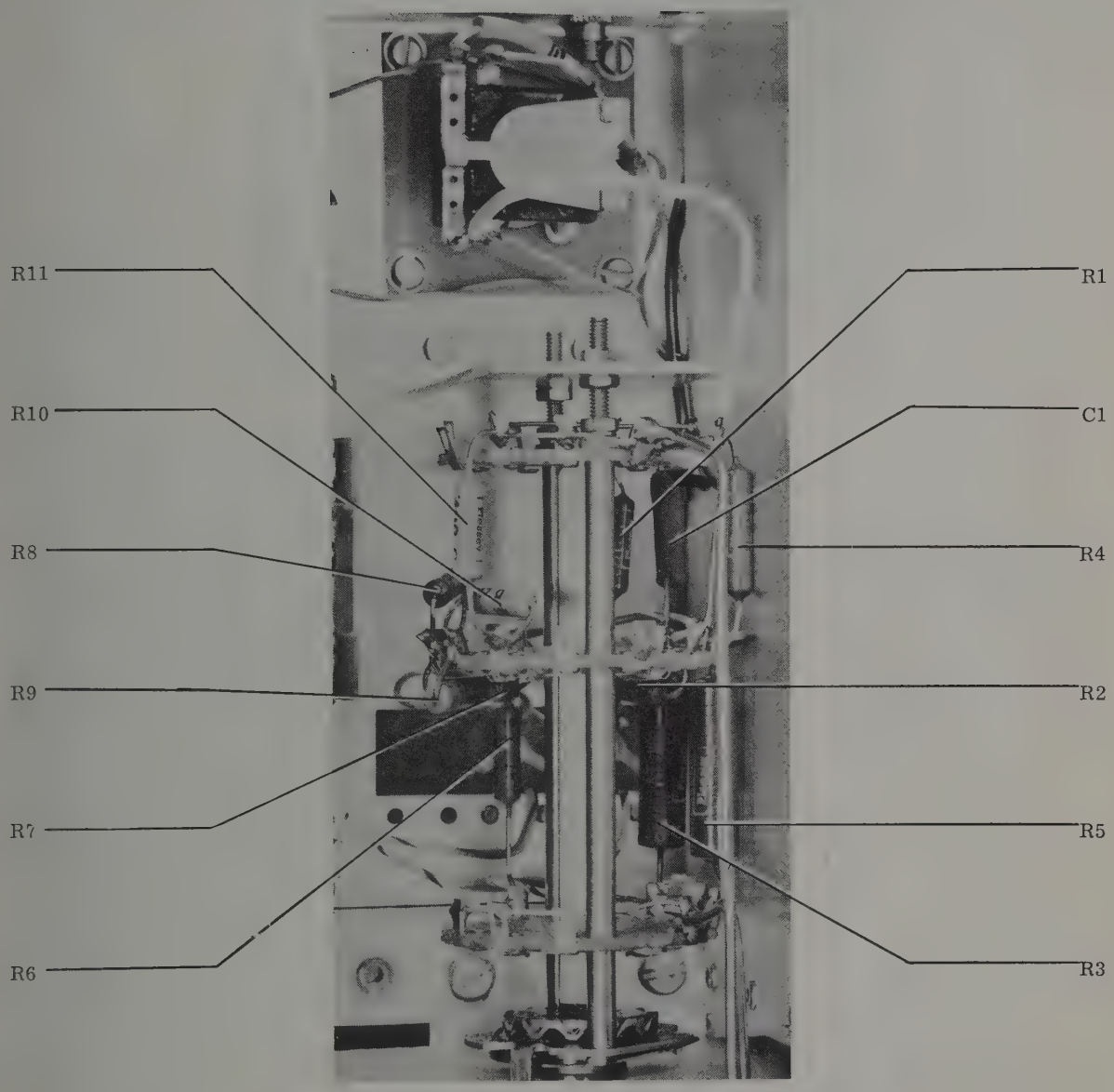
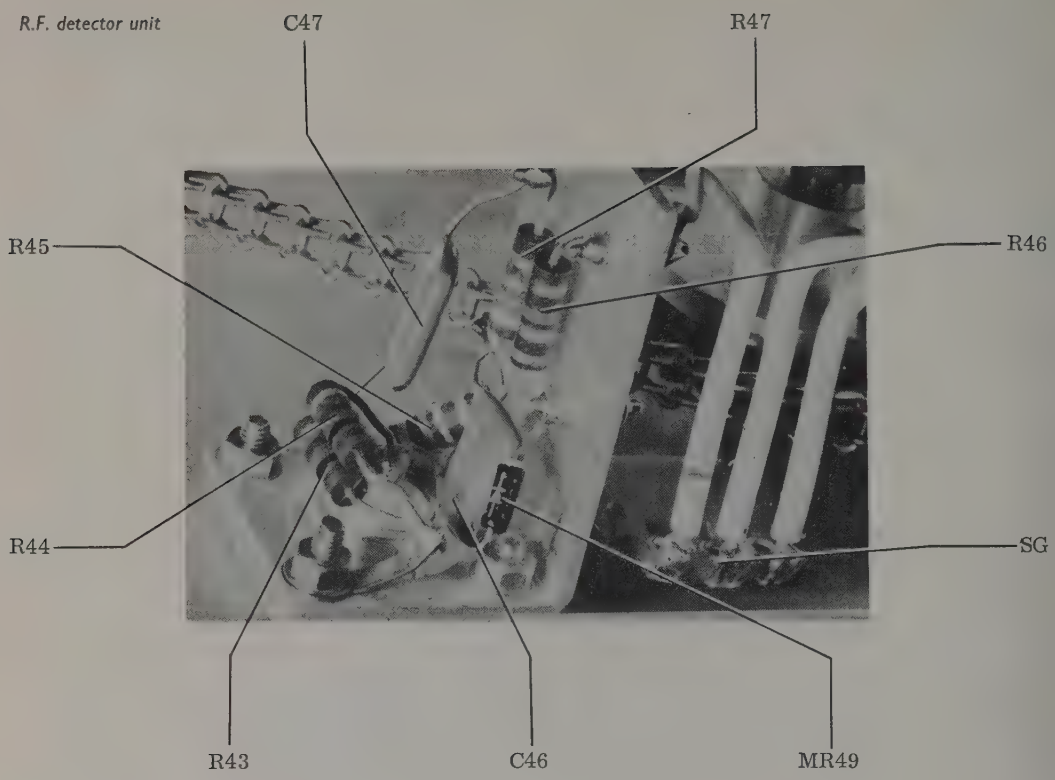


Fig. 5.4b MAX INPUT switch, SA

Fig. 5.5 R.F. detector unit



5.4 REALIGNMENT

5.4.1 Introduction

This is a complete realignment procedure with the steps arranged in a logical order. If the full procedure is not required, for example following a component replacement, individual steps may be performed providing they do not interact with other adjustments. It is recommended that you always consider the effects of any readjustment by reference to the circuit diagrams.

5.4.2 Test equipment required

Item	Type	Minimum specification	Recommended model
a	Oscilloscope	L. F. general purpose	TF 2210, TF 2200, TF 2201.
b	Electronic voltmeter	Sensitivity 0.3 V Standardized 1%	TF 2600.
c	Frequency counter	Frequency 20 Hz to 150 kHz	TF 2411, TF 2414A
d	100 kHz oscillator	Stability: ±1 part in 10^6 per ten minutes. 0.1 Hz discrimination.	
e	L. F. oscillator	Frequency 20 Hz to 1.5 kHz Output 0.3 V to 3 V.	TF 1101
*f	L. F. oscillator	Frequency 20 Hz to 1.5 kHz	TF 1101
g	Meter	100 μA	
h	D. C. voltmeter	20,000 Ω/V	Avo model 8.

* The distortion check described in 5.4.11 entails the use of two L. F. oscillators.

5.4.3 Regulated power supply

Test equipment: b

(a) Connect the voltmeter to the emitter of VT1.

(b) Set the VOLTMETER RANGE switch fully clockwise.

(c) Set the MAX INPUT fully counter clockwise.

(d) Adjust RV260 to give -15 V on the voltmeter.

(e) Connect a lead from the h.t. rail to the input of the wave analyser.

(f) Set the front panel controls to provide the most sensitive range of the instrument.

(g) Check for h.t. ripple at 50 Hz, 100 Hz and 150 Hz. The ripple content should be less than 5 μV.

NOTE: If excessive ripple is present the following components could be suspect: MR260, MR261, MR262, VT1, VT260 or VT261.

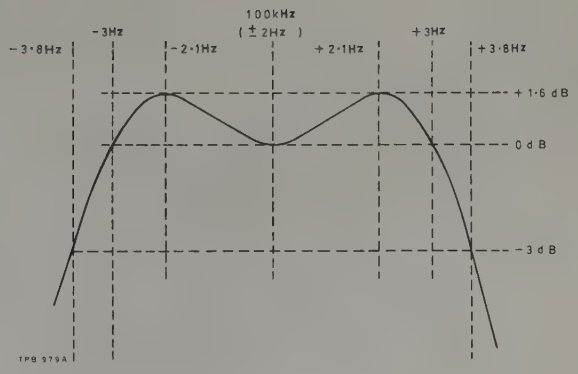


Fig. 5.6 Frequency response of crystals XL140 and XL141 on board TM 7094

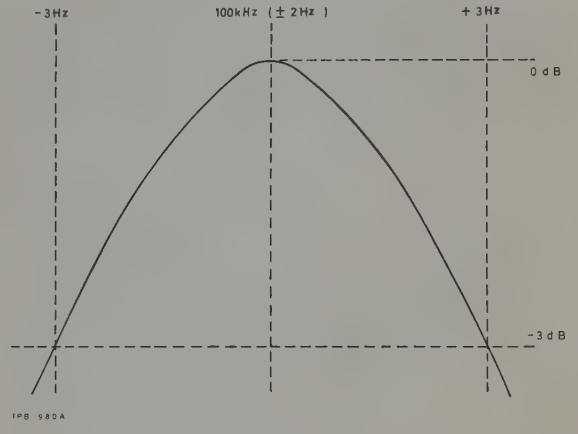


Fig. 5.7 Frequency response of crystal XL160 on board TM 7095

5.4.4 100 kHz I.F. Filters

The I. F. crystal filters consist of two units; a pair of over-coupled crystals mounted on board TM 7094 which gives the frequency response shown in Fig. 5.6, and a single crystal circuit mounted on board TM 7095 which gives the response shown in Fig. 5.7. The combination of these two filters gives the response shown in Fig. 5.8.

Since crystals are prone to aging, the crystal circuits may drift out of claims. In general, the crystal frequencies drift together but, in some cases, differential drift may cause the pass band of the crystal filter to become 'bumpy' or the A. F. C. circuit may no longer hold the signal in the centre of the pass band, or the B. F. O. may no longer lie in the centre of the i.f.

If this occurs, the procedures described below will enable the necessary adjustments to be made.

CAUTION Since the tuning of the crystal filter circuits is very critical, extreme care should be taken in carrying out these instructions.

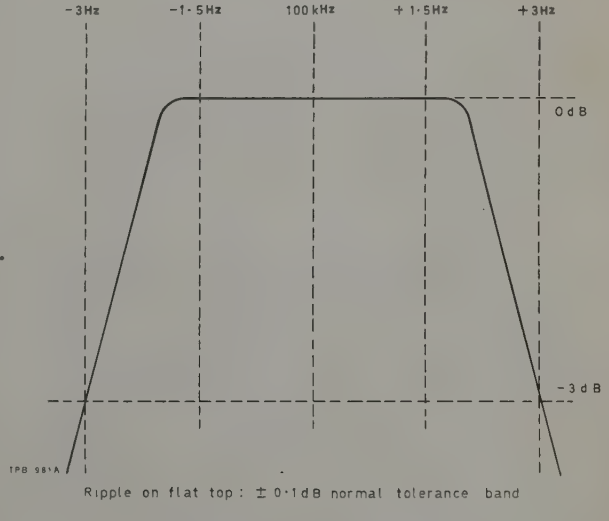


Fig. 5.8 Response waveform derived from the three crystals, XL140, XL141 and XL160

Procedure

Test equipment: c and d

1 Single crystal filter

(a) Set the VOLTMETER RANGE switch fully counter clockwise.

(b) Connect the 100 kHz oscillator, set to approximately 70 μV, to pin 7 on board TM 7095.

(c) Check the response which should be similar to that shown in Fig. 5.7.

(d) Frequency may be adjusted using C172. (C165 may be used for coarse adjustments.)

(e) Bandwidth may be set by adjusting RV160.

NOTE: In order to increase the bandwidth, turn RV160 so that the output increases in amplitude.

2 Two-crystal filter

(a) Remove the ring bridge, TM 7252 (on board TM 9414) from its holder and in its place connect the 100 kc/s oscillator and a 47 Ω resistor, as shown in Fig. 5.9.

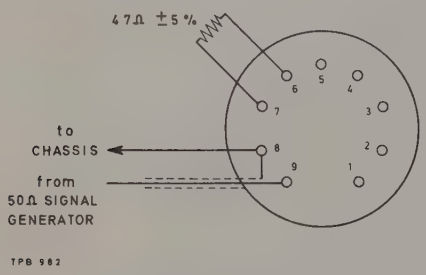


Fig. 5.9 Top view of ring bridge holder, connector B9A

(b) Connect a 0.1 μF capacitor between the junction of R165/XL160 and the base of VT161 on TM 7095.

(c) With an input signal of approximately 20 mV, check the response of the filter which should be similar to that shown in Fig. 5.6.

(d) If necessary adjust the trimmers as follows:

	Low frequency peak	*High frequency peak*
Frequency (fine)	C150	C151
Frequency (coarse)	C142	C146
Bandwidth	RV140	RV141

NOTE: In order to increase the bandwidth, turn RV140 so that the amplitude is reduced and RV141 so that the amplitude is increased.

(e) Remove the 0.1 μF capacitor.

(f) Check the overall frequency response which should be similar to that shown in Fig. 5.8.

(g) It may be necessary to adjust RV160 and C172 marginally to obtain the correct response.

NOTES:

(i) Do not attempt to carry out this procedure unless a 100 kHz oscillator with adequate frequency stability and discrimination is available.

(ii) Check the centre frequency accurately using the frequency counter. If frequency measuring equipment is not available, a standard frequency/Lissajous figure method may be used. The maximum tolerance on the centre frequency is ±2 Hz.

(iii) Use the meter on the instrument for reading levels and response characteristics. The 0 dB on the diagrams is for reference and not necessarily 0 dB on the meter. The oscillator level may be varied to set a convenient measuring point.

(iv) Use non-metallic trimming tools for adjusting the capacitors.

5.4.5 Crystal discriminator alignment

Test equipment: c and e

Should the centre frequency of the crystal discriminator have drifted, the following alignment should be carried out:

(a) Set the zero frequency of the wave analyser.

(b) Connect the audio oscillator, set to 30 Hz, 1 V, to the INPUT.

(c) By varying the audio frequency input explore the pass band of the instrument and set the signal to the centre frequency, i.e. midway between the 3 dB points.

(d) Connect the frequency counter to pin 7 on board TM 7096 and note the output frequency.

(e) Set the FUNCTION switch to A. F. C. and adjust C98 until the output frequency is the same as that noted in (d).

NOTE: If no frequency counter is available, the most practical method of setting the discriminator centre frequency is to tune in a signal for maximum meter reading, set the FUNCTION switch to A. F. C. and adjust C98 for the same reading. The main difficulty which may arise with this method is that, due to the flatness of the centre portion of the pass band, the A. F. C. may be as much as 1 Hz off tune.

5.4.6 Frequency scale alignment

Test equipment: c

CAUTION It is essential that non-magnetic or de-magnetized spanners and trimming tools are used in the following alignment procedure.

(a) Set the FUNCTION switch to B. F. O.

(b) Set the ZERO control to mid-travel.

(c) Connect the frequency counter to the B. F. O. output terminals.

(d) Turn the FREQUENCY dial to 50 kHz.

(e) Remove the cylindrical screening can surrounding the main tuning coil.

(f) Adjust L112 to bring the scale calibration correct at 50 kHz as monitored on the counter.

(g) Turn the FREQUENCY dial to 5 kHz.

(h) Adjust L113 to bring the scale calibration correct at 5 kHz.

(i) Adjust the insertion of the core, L1, to bring the scale calibration correct at 0 Hz (or zero).

NOTES:

(i) Since the B. F. O. will give noise output at zero frequency it is easier to note the zero frequency as being the maximum on the meter.

(ii) The adjustments of L112, L113 and L1 are interdependent and it will be necessary to repeat the adjustments until the frequencies are within the specification for the instrument.

(iii) Adjustment of the core L1 should be kept to a minimum if possible.

(iv) As very small core movements can have considerable effect on the frequency, the cores should be locked after each adjustment.

5.4.7 B.F.O. alignment

Test equipment: c and e

Repeat steps (a), (b), (c) and (d) as in Section 5.4.5.

(e) Switch to A. F. C. Note frequency. This should be the same as that noted in step d, if not, the A. F. C. discriminator requires alignment.

(f) Switch to CALIBRATE. Note the frequency, which should be the same as in steps d and e. If not, adjust C211 on board TM 7121 until the same frequency is obtained.

NOTE: If no frequency counter is available, a Lissajous figure technique could be used. If no oscillator is available, the B. F. O. can be set approximately to the centre of the i. f. pass band by adjusting C211 until the meter reading is at the centre of the flat top of the response curve.

5.4.8 Overall frequency response

Test equipment: b

(a) Set the FUNCTION switch to B. F. O.

(b) Connect the B. F. O. output terminals to the INPUT terminals and monitor at the B. F. O. output with the voltmeter.

(c) Set the MAX INPUT switch to 100 mV and adjust the OUTPUT LEVEL control for f. s. d. on the meter.

(d) Note the meter reading.

(e) Keeping the reading on the voltmeter constant by means of the OUTPUT LEVEL control, check the frequency response of the TF 2330 from 20 Hz to 76 kHz.

(f) Adjust C3 to give a flat response over this range.

(g) Check that the signal levels at 400 Hz and 76 kHz are within ±3% of each other.

(h) Set the MAX INPUT switch to 300 mV and adjust the OUTPUT LEVEL control for f. s. d. on the meter.

(i) Repeat checks (e) and (f) above.

(j) Adjust C2 to give a flat response over this range.

(k) Repeat check (h).

(l) Finally check the frequency response from 20 Hz to 76 kHz at the following positions of the MAX INPUT switch: 1 V, 3 V, 10 V, 30 V, 100 V and 300 V, adjusting the VOLTMETER RANGE switch as necessary.

(m) Repeat check (h) on each range.

5.4.9 Calibration signal level

Test equipment: b, c and e

To carry out this check a standardized 1 V, 400 Hz signal is required. The desired accuracy can be obtained by using an audio oscillator (TF 1101), and monitoring its output with a valve voltmeter (TF 2600). The distortion on the input signal should be less than 1%.

(a) Set the FUNCTION switch to NORMAL.

(b) Set the VOLTMETER/RELATIVE switch to VOLTMETER.

(c) Switch the MAX INPUT range to 1 V.

(d) Turn the VOLTMETER RANGE switch fully counter clockwise.

(e) Feed the standardized 400 Hz, 1 V signal from the signal generator to the INPUT terminals of the instrument.

(f) Tune the TF 2330A for a maximum reading on the meter.

(g) Adjust the SET CALIBRATION control to give f. s. d. on the meter.

(h) Set the FUNCTION switch to CALIBRATE.

(i) The meter should now read f. s. d., if not, adjust RV210 to obtain this.

(j) Finally, using the SET CALIBRATE and the SET REFERENCE controls, check the cover of the SET CALIBRATION control. The range coverage should be from at least +2 dB to -6 dB. If the coverage is insufficient, reset RV6 and then repeat the tests in this section.

5.4.10 External meter check

Test equipment: f

(a) Set up the TF 2330A so that the meter reads f. s. d.

(b) Plug the 100 μA meter, with a total series resistance of 2.5 kΩ, into the EXT MONITOR socket. The internal meter reading should not change by more than 0.5%.

(c) If the change is greater than 0.5%, adjust RV190. Repeat (a) and (b).

5.4.11 Distortion check and alignment

Test equipment: e and f. Hybrid input circuit or equivalent.

Two L. F. Oscillators are required to feed in two separate frequencies to the wave analyser via the Hybrid network, see Fig. 5.10.

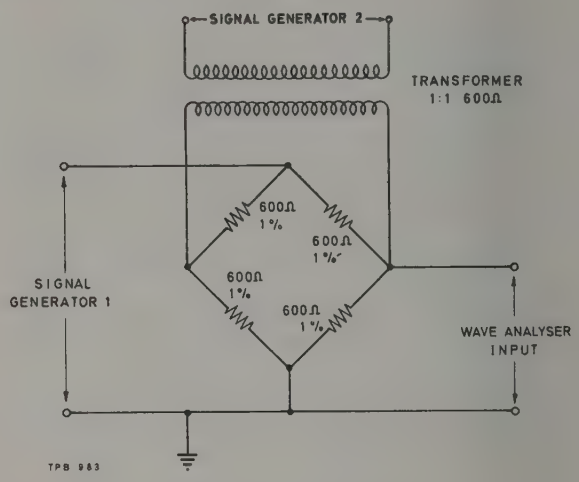


Fig. 5.10 Hybrid input circuit

The controls of the wave analyser should be set as follows:

Meter slider switch to VOLTMETER.

VOLTMETER RANGE switch to 0 dB.

MAX INPUT switch to a convenient position to suit input from oscillators.

Procedure

(a) Set Oscillator 1 to 700 Hz.

(b) Set Oscillator 2 to 1025 Hz.

(c) Tune the wave analyser to peak at 700 Hz and adjust the level from oscillator 1 so that the meter reads $\frac{1}{2}$ f. s. d.

(d) Tune the wave analyser to 1025 Hz and adjust the level from oscillator 2 so that the meter reads $\frac{1}{2}$ f. s. d.

(e) Tune the TF 2330A to the difference frequency, i. e. 325 Hz and adjust tuning for a maximum reading.

NOTE: If there is no reading evident on the meter, the MAX INPUT control may be turned down until a reading is obtained and then returned to the original setting.

(f) Adjust RV51 for minimum reading on the meter.

(g) Tune the wave analyser to peak at 375 Hz.

(h) Adjust RV51 again for a minimum reading on the meter.

(i) Tune to 325 Hz and 375 Hz, each time adjusting RV51, until the best compromise has been obtained.

(j) The distortion has now been adjusted to a minimum overall level.

5.4.12 Residual noise and hum

(a) Set the FUNCTION switch to NORMAL.

(b) Set the MAX INPUT to 300 V.

(c) Turn the VOLTMETER RANGE switch to 60 dB.

(d) Tune the instrument over its entire frequency range, 20 Hz to 76 kHz, and ensure that the meter reading is not greater than 2% of f. s. d. at any point.

NOTE: At the mains supply frequency and mains multiples the meter reading should not be greater than 6% of f. s. d. A reading greater than 2% of f. s. d. is a sure indication of a fault in the instrument. Fig. 5. 11 provides an easy to follow procedure for tracing the fault by a process of elimination.

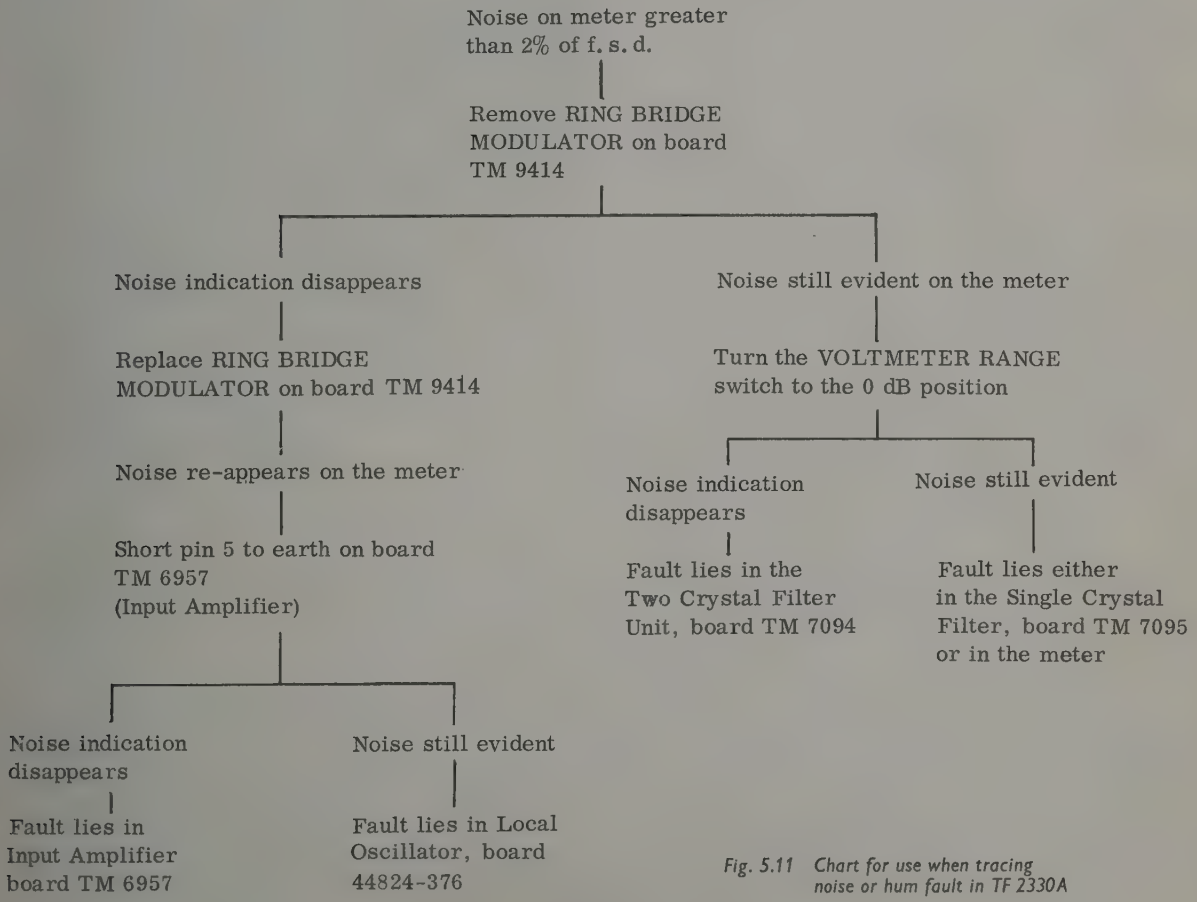

Noise on meter greater than 2% of f. s. d.
Remove RING BRIDGE MODULATOR on board TM 9414
Noise indication disappears
Noise still evident on the meter
Replace RING BRIDGE MODULATOR on board TM 9414
Turn the VOLTMETER RANGE switch to the 0 dB position
Noise re-appears on the meter
Noise indication disappears
Noise still evident
Short pin 5 to earth on board TM 6957 (Input Amplifier)
Fault lies in the Two Crystal Filter Unit, board TM 7094
Fault lies either in the Single Crystal Filter, board TM 7095 or in the meter
Noise indication disappears
Noise still evident
Fault lies in Input Amplifier board TM 6957
Fault lies in Local Oscillator, board 44824-376

Fig. 5.11 Chart for use when tracing noise or hum fault in TF 2330A

Chapter 6

Replaceable parts

Introduction

This section lists replaceable parts in alphabetical order of their circuit references, with miscellaneous parts at the end of the list. The following abbreviations and symbols are used:

C : capacitor
Carb : carbon
Cer : ceramic
CRT : cathode ray tube
Elec : electrolytic
FS : fuse
JK : jack
L : inductor
Log : logarithmic law
M : meter
Met : metal
Min : minimum value
MR : semiconductor diode
Ox : oxide
PL : plug
Plas : plastic
R : resistor
RV : variable resistor
S : switch
SKT : socket
T : transformer
TE : total excursion
TH : thermistor
TP : terminal
V : valve
Var : variable
VT : transistor
WW : wirewound
XL : crystal
† : value selected during test; nominal value listed.
Ø : feed-through component
W : watts at 70 °C
W* : watts at 55 °C
W** : watts at 40 °C
W*** : watts at 20 °C
W° : watts at unspecified temperature

One or more of the parts fitted to the instrument may differ from those listed in this chapter for any of the following reasons:

(a) Components indicated by † have their value selected during test to achieve particular performance limits.

(b) Owing to supply difficulties components may be substituted by others of different type or value provided that the overall performance of the instrument is maintained.

(c) As part of a policy of continuous development, components may be changed in value or type to obtain detail improvements in performance.

Wherever there is such a difference between the component fitted and the one listed, always use as a replacement the same type and value as found in the instrument.

Ordering

Send your order for replacement parts to our Service Division at the address given on the back cover. Specify the following information for each part required:

1) Type and serial number of instrument
2) Circuit reference
3) Description
4) M.I. code number

If a part is not listed, state its function, location and description when ordering.

Circuit reference	*Description*	*M.I. code*
C1	Cer 100pF 2% 750V	26324-897
C2	Cer 8-50pF Var	26845-108
C3	Cer 8-50pF Var	26845-108
C6	Elec 100µF +100-20% 25V	26417-158
C7	Air 6-92.4pF Var	26812-173
C9	Elec 500µF +50-20% 15V	26417-173
C10	Plas 0.001µF 20% 500V	26174-125
C46	Mica 100pF 2% 350V	26272-315
C47	Mica 100pF 2% 350V	26272-315
C50	Elec 250µF +100-20% 25V	26417-167
C51	Plas 1µF 10% 400V	26512-284
C52	Elec 25µF +100-20% 35V	26417-143
C53	Elec 1000µF +50-20% 12V	26417-403
C54	Elec 100µF +100-20% 6V	26417-154

Circuit reference	Description	M.I. code
C55	Elec 100µF +100-20% 6V	26417-154
C56	Mica 1800pF 5% 200V	26268-366
C57	Elec 100µF 20% 10V	26486-606
C75	Mica 4700pF 2% 200V	26268-389
C76	Plas 0.01µF 20% 400V	26174-147
C77	Elec 5µF +50-20% 70V	26417-118
C78	Mica 1070pF 1% 350V	26268-361
C79	Mica 1640pF 1% 200V	26268-365
C80	Mica 2810pF 1% 200V	26268-374
C81	Mica 355pF 1% 350V	26268-394
C82	Mica 2610pF 1% 200V	26268-372
C83	Mica 3410pF 1% 200V	26268-378
C84	Mica 567pF 1% 350V	26268-395
C85	Cer 22pF 5% 750V	26324-807
C90	Elec 50µF +100-20% 25V	26417-152
C91	Mica 0.001µF 1% 350V	26268-360
C92	Plas 0.1µF 25% 350V	26174-173
C93	Plas 0.1µF 25% 350V	26174-173
C94	Mica 68pF 1% 350V	26268-317
C95	Mica 100pF 1% 350V	26268-324
C96	Plas 0.25µF 10% 50V	26174-175
C97	Cer 3-40pF Var	26848-215
C98	Cer 3-40pF Var	26848-215
C99	Cer 10-40pF Var	26847-265
C100	Plas 0.1µF 25% 350V	26174-173
C101	Elec 330µF 20% 6V	26486-630
C102	Elec 330µF 20% 6V	26486-630
C110	Elec 100µF 20% 10V	26486-606
C111	Plas 0.1µF 20% 250V	26582-208
C112	Mica 8140pF 0.5% 350V	26257-380
C113	Cer 390pF 10% 500V	26361-924
C114	Elec 100µF 20% 10V	26486-606
C115	Elec 25µF +100-20% 25V	26417-143
C116	Plas 0.01µF 20% 400V	26582-232
C117†	Plas 0.1µF 20% 250V	26582-208
C118	Plas 0.1µF 20% 250V	26582-208
C119	Plas 0.01µF 20% 400V	26582-232
C120	Elec 100µF 20% 10V	26486-606
C121	Plas 0.01µF 20% 400V	26582-232
C122	Plas 0.1µF 20% 250V	26582-208
C123	Plas 0.01µF 20% 400V	26582-232
C124	Plas 0.25µF 10% 150V	26174-175
C140	Plas 0.01µF 20% 400V	26174-147
C141	Mica 33pF 5% 350V	26268-308
C142	Air 3-34pF Var	26812-314
C143	Mica 800pF 5% 350V	26268-356
C144	Plas 0.1µF 25% 350V	26174-173
C145	Mica 33pF 5% 350V	26268-308
C146	Air 3-34pF Var	26812-314
C147	Mica 0.001µF 1% 350V	26268-360
C148	Plas 0.1µF 25% 350V	26174-173
C149	Elec 5µF +50-20% 70V	26417-118
C150	Air 3-12.15pF Var	26812-311
C151	Air 3-12.15pF Var	26812-311
C160	Plas 0.04µF 20% 200V	26174-161
C161	Mica 0.001µF 1% 350V	26268-360
C162	Plas 0.1µF 25% 350V	26174-173
C163	Plas 0.1µF 25% 350V	26174-173
C164	Mica 33pF 5% 350V	26268-308
C165	Air 3-34pF Var	26812-314
C166	Plas 0.1µF 25% 350V	26174-173
C167	Plas 0.25µF 10% 150V	26174-175
C168	Plas 0.25µF 10% 150V	26174-175
C169	Elec 5µF +100-20% 15V	26414-113
C170	Elec 5µF +50-20% 70V	26417-118
C171	Plas 0.04µF 20% 200V	26174-161
C172	Air 3-12.15pF Var	26812-311
C191	Elec 5µF +50-20% 70V	26417-118

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
C192	Elec 5μF +50-20% 70V	26417-118
C193	Elec 5μF +50-20% 70V	26417-118
C194	Plas 0.25μF 10% 150V	26174-175
C195	Plas 0.1μF 25% 350V	26174-173
C196	Plas 0.25μF 10% 150V	26174-175
C197	Plas 0.25μF 10% 150V	26174-175
C198	Plas 0.1μF 25% 350V	26174-173
C210	Plas 100μF +100-20% 25V	26417-158
C211	Cer 3-40pF Var	26848-215
C212	Mica 22pF 5% 350V	26268-303
C213	Plas 0.1μF 25% 350V	26174-173
C214	Plas 0.04μF 20% 200V	26174-161
C215	Plas 0.1μF 25% 350V	26174-173
C216	Elec 25μF +100-20% 25V	26417-143
C217	Elec 100μF +100-20% 6V	26417-154
C218	Elec 5μF +50-20% 70V	26417-118
C219	Elec 100μF +100-20% 25V	26417-158
C220	Plas 0.02μF 20% 200V	26174-151
C245	Elec 100μF +100-20% 6V	26417-154
C246	Elec 100μF +100-20% 6V	26417-154
C247	Elec 100μF +100-20% 25V	26417-158
C248	Elec 500μF +100-20% 15V	26417-173
C249	Mica 1070pF 1% 350V	26268-361
C250	Mica 1640pF 1% 200V	26268-365
C251	Mica 2810pF 1% 200V	26268-374
C252	Mica 355pF 1% 350V	26268-394
C253	Mica 2610pF 1% 200V	26268-372
C254	Mica 3410pF 1% 200V	26268-378
C255	Mica 567pF 1% 350V	26268-395
C260	Elec 500μF +100-20% 50V	26417-178
C261	Elec 500μF +100-20% 50V	26417-178

Circuit reference	Description	M.I. code
C262	Plas 0.04μF 10% 200V	26174-161
C263	Elec 50μF +100-20% 25V	26417-152
C264	Elec 250μF +100-20% 25V	26417-167
C265	Elec 25μF +100-20% 70V	26417-145
C266 †	Plas 100pF 2% 125V	26516-241
FS1	Delay 50mA (230V range) 100mA (115V range)	23411-051 23411-052
FS2	Quick blow 160mA	23411-003
JK1	Socket, 2 pole	23421-685
L1	Var inductor (FREQÚENCY)	44161-403
L72	Inductor	44264-865
L73	Inductor	44266-837
L74	Inductor	44262-856
L90	Inductor	44266-819
L91	Inductor	44263-203
L111	Inductor	44272-416
L112	Var inductor	44243-204
L113	Var inductor	44272-419
L114	Inductor	44272-416
L190	Inductor	44272-416
L191	Inductor	44272-416
L242	Inductor	44264-865
L243	Inductor	44266-837
L244	Inductor	44262-856
M1	800Ω 100μA	44572-202
MR1	1N540	28357-048

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
MR49	CG91H	28321-311
MR50	1S920	28336-138
MR51	1S920	28336-138
MR70	AAZ12	28331-618
MR71	AAZ12	28331-618
MR72	AAZ12	28331-618
MR73	AAZ12	28331-618
MR90	CG85-H	28321-201
MR91	CG85-H	28321-201
MR110	SC15	28381-325
MR111	Z6.2 5%	28371-486
MR112	HG1005	28323-035
MR113	HG1005	28323-035
MR114	HG1005	28323-035
MR190	CG85-H	28321-201
MR191	CG85-H	28321-201
MR192	HG1005	28323-035
MR193	HG1005	28323-035
MR210	HG1005	28323-035
MR211	Z6.2 5%	28371-486
MR212	HG1005	28323-035
MR213	HG1005	28323-035
MR240	AAZ12	28331-618
MR241	AAZ12	28331-618
MR242	AAZ12	28331-618
MR243	AAZ12	28331-618
MR260	1N540	28357-048
MR261	1N540	28357-048
MR262	Z10 10%	28371-846

Circuit reference	Description	M.I. code
PL1	3 pin 3A	23423-151
RLA	350Ω 12V	23486-110
R1	Met film 3300Ω 1% ¼W	24637-201
R2	Met film 7811Ω 1% ¼W	24637-401
R3	Met film 90kΩ 1% 1W	24667-651
R4	Met film 46.2kΩ 1% ½W	24657-201
R5	Met film 68.37kΩ 1% 1W	24667-601
R6	Met film 990kΩ 1% ¼W	24637-851
R7	Met film 7.840kΩ 1% ¼W	24637-402
R8	Met film 2.250kΩ 1% ¼W	24637-104
R9	Met film 693Ω 1% ¼W	24636-801
R10	Met film 217Ω 1% ¼W	24636-604
R11	Met film 100Ω 1% ¼W	24636-601
R12	Carb 4.7kΩ 10% ½W*	24342-100
R15	Met ox 820Ω 5% ½W	24552-078
R16	Met film 1297Ω ½% ¼W	24635-003
R17	Met film 877.5Ω ½% ¼W	24634-802
R18	Met film 1297Ω ½% ¼W	24635-003
R19	Met film 877.5Ω ½% ¼W	24634-802
R20	Met film 1297Ω ½% ¼W	24635-003
R21	Met film 877.5Ω ½% ¼W	24634-802
R22	Met film 1297Ω ½% ¼W	24635-003
R23	Met film 877.5Ω ½% ¼W	24634-802
R24	Met film 1297Ω ½% ¼W	24635-003
R25	Met film 877.5Ω ½% ¼W	24634-802
R26	Met film 1297Ω ½% ¼W	24635-003
R27	Met film 600Ω ½% ¼W	24634-801
R28	Carb 10kΩ 10% ½W*	24342-110
R43	Carb 100Ω 10% ½W	24342-050
R44	Carb 100Ω 10% ½W	24342-050
R45	Carb 47kΩ 5% ¼W	24332-126
R46	Carb 2.2MΩ 5% ¼W	24332-174
R47	Carb 47kΩ 5% ¼W	24332-126
R50	Carb 100Ω 10% ½W*	24342-050

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R51	Met ox 10kΩ 5% ½W	24552-110
R52	Met ox 8.2kΩ 5% ½W	24552-108
R53	Met film 96kΩ 1% ¼W	24637-651
R54	WW 3.3kΩ 5% 8W***	25125-652
R55	Carb 22kΩ 10% ½W*	24342-118
R56	Met ox 510Ω 5% ½W	24552-071
R57	Carb 4.7kΩ 10% ½W*	24342-100
R58	Met ox 2.7kΩ 5% ½W	24552-092
R59	Met ox 3.9kΩ 5% ½W	24552-096
R60	Met ox 22kΩ 5% ½W	24552-118
R61	Met ox 1.2kΩ 5% ½W	24552-082
R62	Met ox 3.3kΩ 5% ½W	24552-094
R63	Carb 2.7kΩ 10% ½W*	24342-092
R70	Met film 1kΩ 1% ¼W	24637-101
R71	Met ox 510Ω 5% ½W	24552-071
R72	Met ox 750Ω 5% ½W	24552-077
R73	Met ox 430Ω 5% ½W	24552-067
R74 †	Met ox 820Ω 5% ½W	24552-078
R75 †	Met ox 820Ω 5% ½W	24552-078
R76	Met film 1kΩ 1% ¼W	24637-101
R77	Met film 1kΩ 1% ¼W	24637-101
R78	Met film 1kΩ 1% ¼W	24637-101
R79	Met film 1kΩ 1% ¼W	24637-101
R80	Met film 1kΩ 1% ¼W	24637-101
R81	Met film 1kΩ 1% ¼W	24637-101
R82	Carb 33kΩ 10% ½W*	24342-122
R83	Carb 33kΩ 10% ½W*	24342-122
R84	Carb 6.8kΩ 10% ½W*	24342-106
R85	Carb 100Ω 10% ½W*	24342-050
R90	Carb 100Ω 10% ½W*	24342-050
R91	Carb 6.8kΩ 10% ½W*	24342-106
R92	Carb 22kΩ 10% ½W*	24342-118
R93	Carb 1.5kΩ 10% ½W*	24342-084
R94	Met ox 100Ω 5% ½W	24552-050
R95	Carb 2.2kΩ 10% ½W*	24342-088
R96	Met ox 6.8kΩ 5% ½W	24552-106
R97	Met ox 330Ω 5% ½W	24552-063
R98	Carb 100kΩ 10% ½W*	24342-135
R99	Carb 100kΩ 10% ½W*	24342-135
R100	Met ox 220Ω 5% ½W	24552-058
R101	Carb 2.2MΩ 10% ½W*	24342-174
R110	Carb 6.8kΩ 10% ½W*	24342-106
R111	Carb 3.9kΩ 10% ½W*	24342-096
R112	Carb 68Ω 10% ½W*	24342-043
R113	Carb 47kΩ 10% ½W*	24342-126
R114	Carb 15kΩ 10% ½W*	24342-114
R115	Carb 470Ω 10% ½W*	24342-069
R116	Carb 820Ω 10% ½W*	24342-078
R117	Carb 820Ω 10% ½W*	24342-078
R118	Carb 4.7kΩ 10% ½W*	24342-100
R119	Met ox 2.2kΩ 5% ½W	24552-088
R120	Met ox 33kΩ 5% ½W	24552-122
R121	Met ox 9.1kΩ 5% ½W	24552-109
R122	Carb 2.2kΩ 10% ½W*	24342-088
R123	Carb 3.3kΩ 10% ½W*	24342-094
R124	Met ox 560Ω 5% ½W	24552-072
R125	Carb 4.7kΩ 10% ½W*	24342-100
R126	Carb 10Ω 10% ½W*	24342-020
R127	Carb 10Ω 10% ½W*	24342-020
R128	Met ox 150Ω 5% ½W	24552-054
R129	Met ox 1kΩ 5% ½W	24552-080
R130	Met ox 2.2kΩ 5% ½W	24552-088
R131	Carb 330Ω 10% ½W*	24342-063
R132	Met ox 10kΩ 5% ½W	24552-110
R133	Carb 39kΩ 10% ½W*	24342-124
R134	Carb 100Ω 10% ½W*	24342-050
R140	Met ox 300Ω 5% ½W	24552-062
R141	Carb 27kΩ 10% ½W*	24342-120
R142	Carb 15kΩ 10% ½W*	24342-114
R143	Met ox 300Ω 5% ½W	24552-062

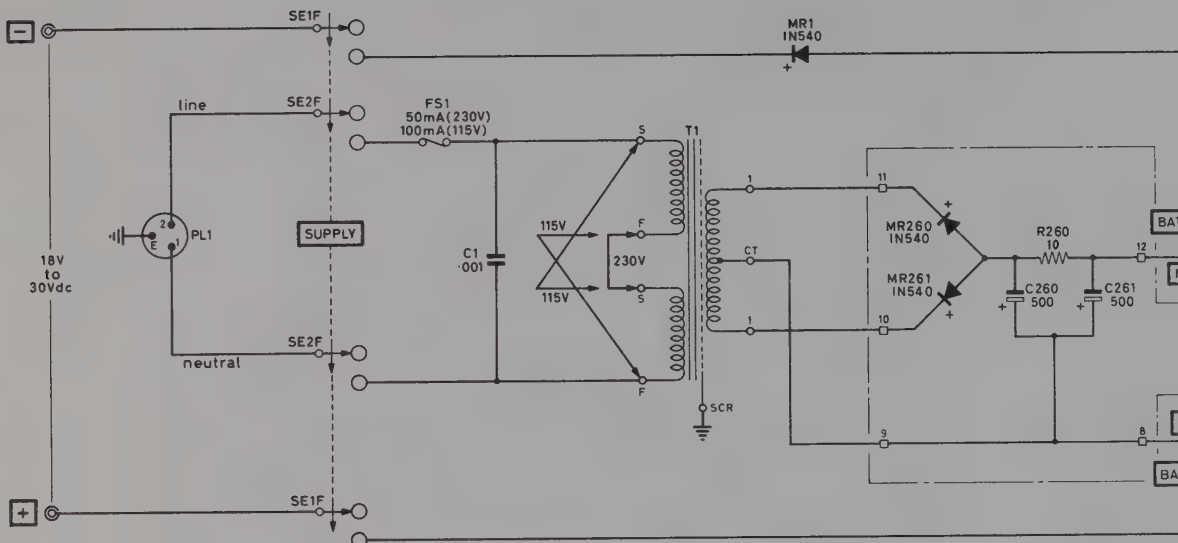
For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R144	Carb 33kΩ 10% ½W*	24342-122
R145	Carb 4.7kΩ 10% ½W*	24342-100
R146	Met ox 180Ω 5% ½W	24552-056
R147	Carb 100Ω 10% ½W*	24342-050
R160	Carb 15kΩ 10% ½W*	24342-114
R161	Carb 33kΩ 10% ½W*	24342-122
R162	Carb 4.7kΩ 10% ½W*	24342-100
R163	Met ox 180Ω 5% ½W	24552-056
R164	Carb 100Ω 10% ½W*	24342-050
R165	Met ox 820Ω 5% ½W	24552-078
R166	Carb 6.8kΩ 10% ½W*	24342-106
R167	Met ox 1kΩ 5% ½W	24552-080
R168	Carb 33kΩ 10% ½W*	24342-122
R169	Carb 2.2kΩ 10% ½W*	24342-088
R170	Met ox 180Ω 5% ½W	24552-056
R171	Carb 8.2kΩ 10% ½W*	24342-108
R172	Met ox 27kΩ 5% ½W	24552-120
R173	Carb 6.8kΩ 10% ½W*	24342-106
R174	Carb 3.3kΩ 10% ½W*	24342-094
R175	Carb 10kΩ 10% ½W*	24342-110
R176	Carb 33kΩ 10% ½W*	24342-122
R177	Carb 2.2kΩ 10% ½W*	24342-088
R178	Carb 100Ω 10% ½W*	24342-050
R179	Carb 4.7kΩ 10% ½W*	24342-100
R190	Met ox 4.7kΩ 5% ½W	24552-100
R191	Met ox 33kΩ 5% ½W	24552-122
R192	Carb 100Ω 10% ½W*	24342-050
R193	Met ox 5.6Ω 5% ½W	24552-016
R194	Carb 1.8kΩ 10% ½W*	24342-086
R195	Carb 8.2kΩ 10% ½W*	24342-108
R196	Carb 2.7kΩ 10% ½W*	24342-092
R197	Met ox 270Ω 5% ½W	24552-061
R198	Carb 1.2kΩ 10% ½W*	24342-082
R199	Carb 2.2kΩ 10% ½W*	24342-088
R200	Carb 100kΩ 10% ½W*	24342-135
R210	Carb 470Ω 10% ½W*	24342-069
R211	Carb 27kΩ 10% ½W*	24342-120
R212	Carb 2.2kΩ 10% ½W*	24342-088
R213	Carb 5.6kΩ 10% ½W*	24342-103
R214	Carb 820Ω 10% ½W*	24342-078
R215	Carb 22kΩ 10% ½W*	24342-118
R216	Carb 22kΩ 10% ½W*	24342-118
R217	Carb 6.8kΩ 10% ½W*	24342-106
R218	Carb 1kΩ 10% ½W*	24342-080
R219	Carb 10kΩ 10% ½W*	24342-110
R220	Carb 3.3kΩ 10% ½W*	24342-094
R221	Met ox 3.9kΩ 5% ½W	24552-096
R222	Met ox 680Ω 5% ½W	24552-076
R223	Carb 22kΩ 10% ½W*	24342-118
R224	Carb 18kΩ 10% ½W*	24342-116
R226	Carb 22kΩ 10% ½W*	24342-118
R227	Carb 1kΩ 10% ½W*	24342-080
R228	Met ox 10kΩ 5% ½W	24552-110
R240	Met ox 1kΩ 5% ½W	24552-080
R241	Met ox 1kΩ 5% ½W	24552-080
R242	Met ox 220Ω 5% ½W	24552-058
R243	Met ox 220Ω 5% ½W	24552-058
R244	Met ox 4.7kΩ 5% ½W	24552-100
R245	Met ox 12kΩ 5% ½W	24552-112
R246	Carb 100Ω 10% ½W*	24342-050
R247	Met ox 3.3kΩ 5% ½W	24552-094
R248	Met ox 180Ω 5% ½W	24552-056
R249	Met ox 10kΩ 5% ½W	24552-110
R250	Met ox 4.7kΩ 5% ½W	24552-100
R251	Met ox 2.2kΩ 5% ½W	24552-088
R252	Met ox 22kΩ 5% ½W	24552-118
R253	Met ox 330kΩ 5% ½W	24552-063
R254	Met ox 1.5kΩ 5% ½W	24552-084
R260	WW 47Ω 5% 6W***	25125-337
R261	Carb 10kΩ 10% ½W*	24342-110

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R262	Carb 10kΩ 10% ½W*	24342-110
R263	Carb 3.9kΩ 10% ½W*	24342-096
R264	Met ox 3.9kΩ 5% ½W	24552-096
R265	Met ox 1.8kΩ 5% ½W	24552-086
R266	Carb 4.7kΩ 10% ½W*	24342-100
RV1	WW 2.5kΩ 10% 1W°	25853-127
RV2	WW 500Ω 10% 3W°	25823-408
RV3	WW 500Ω 10% 3W°	25823-408
RV4	WW 1kΩ 10% 1W°	25815-315
RV5	WW 600Ω 10% 1W°	25814-310
RV6	Carb 10kΩ 20% ¼W°	25611-213
RV50	Carb 15kΩ 20% ¼W	25611-128
RV51	Carb 4.7kΩ 20% ¼W	25611-122
RV90	WW 1kΩ 10% 1W°	25811-538
RV140	WW 1kΩ 10% 1W°	25811-542
RV141	WW 1kΩ 10% 1W°	25811-542
RV160	WW 1kΩ 10% 1W°	25811-538
RV190	Carb 470Ω 20% ¼W°	25611-110
RV191	Carb 1kΩ 20% ¼W°	25611-114
RV210	WW 1kΩ 10% 1W°	25811-538
RV260	Carb 1kΩ 20% ¼W	25611-114
SA	MAX INPUT	44325-802
SB	VOLTMETER/RELATIVE	23467-115
SC	VOLTMETER RANGE	44325-107
SD	FUNCTION	44323-704
SE	SUPPLY	44321-406
SF	BATTERY/MAINS	23467-119
SG	R.F. DETECTOR	23467-116
SKT 1	50Ω N TYPE	23443-733
T1	Mains	43453-006
T70	Modulator	44266-212
T71	Modulator	44264-009
T110	Coupling	44268-416
T140	I.F. 100kHz	44266-820
T160	I.F. 100kHz	44266-820
T240	Modulator	44267-402
T241	Modulator	44267-402
TP1	Test point	23421-086
VT1	OC25	28424-807
VT50	NKT0007	28432-184
VT51	NKT0007	28432-184
VT52	2N404	28423-508
VT70	2N404	28423-508
VT90	NKT677	28422-714
VT110	HT101	28432-735
VT111	HT101	28432-735
VT112	HT101	28432-735
VT113	2N404	28423-508
VT114	2N1304	28443-528
VT115	2N404	28423-508
VT140	NKT677	28422-714
VT160	NKT677	28422-714
VT161	2N404	28423-508
VT162	2N404	28423-508
VT163	2N404	28423-508
VT190	NKT677	28422-714
VT191	2N404	28423-508
VT210	2N1304	28443-528
VT211	2N404	28423-508
VT212	HT100	28432-725
VT213	HT100	28432-725
VT240	2N404	28423-508
VT241	2N404	28423-508
VT242	2N1304	28443-528
VT260	2N404	28423-508
VT261	ACY17	28426-497
XL90, XL140, XL141, XL160	Specially selected set of four crystals Type Salford JC/QC 855	44524-305

For symbols and abbreviations see introduction to this chapter


SE1F
MR1
IN540
line
SE2F
FS1
50mA(230V)
100mA(115V)
T1
PL1
SUPPLY
C1
·001
115V
230V
115V
MR260
IN540
MR261
IN540
R260
10
C260
500
C261
500
18V
to
30Vdc
neutral
SE2F
SCR
SE1F

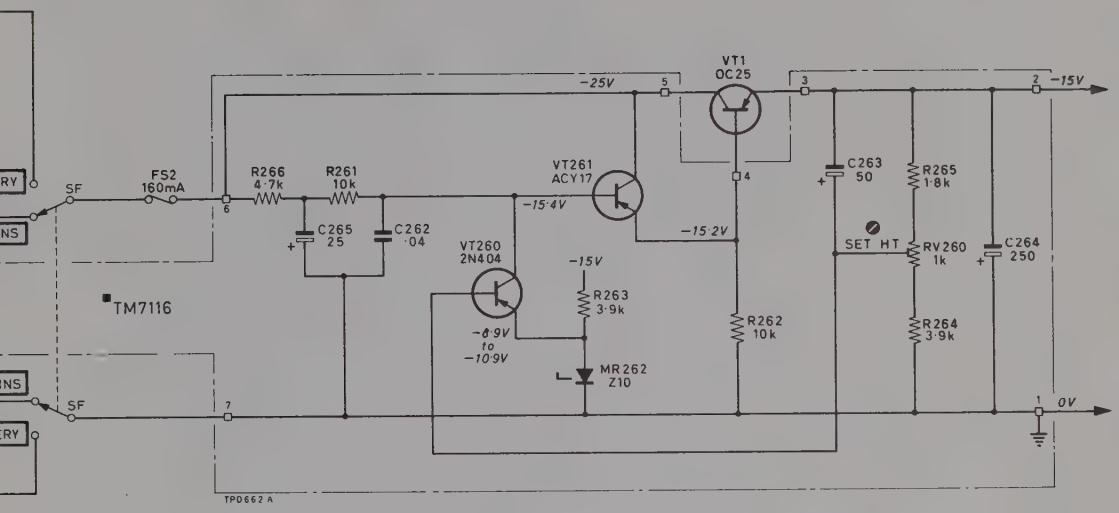
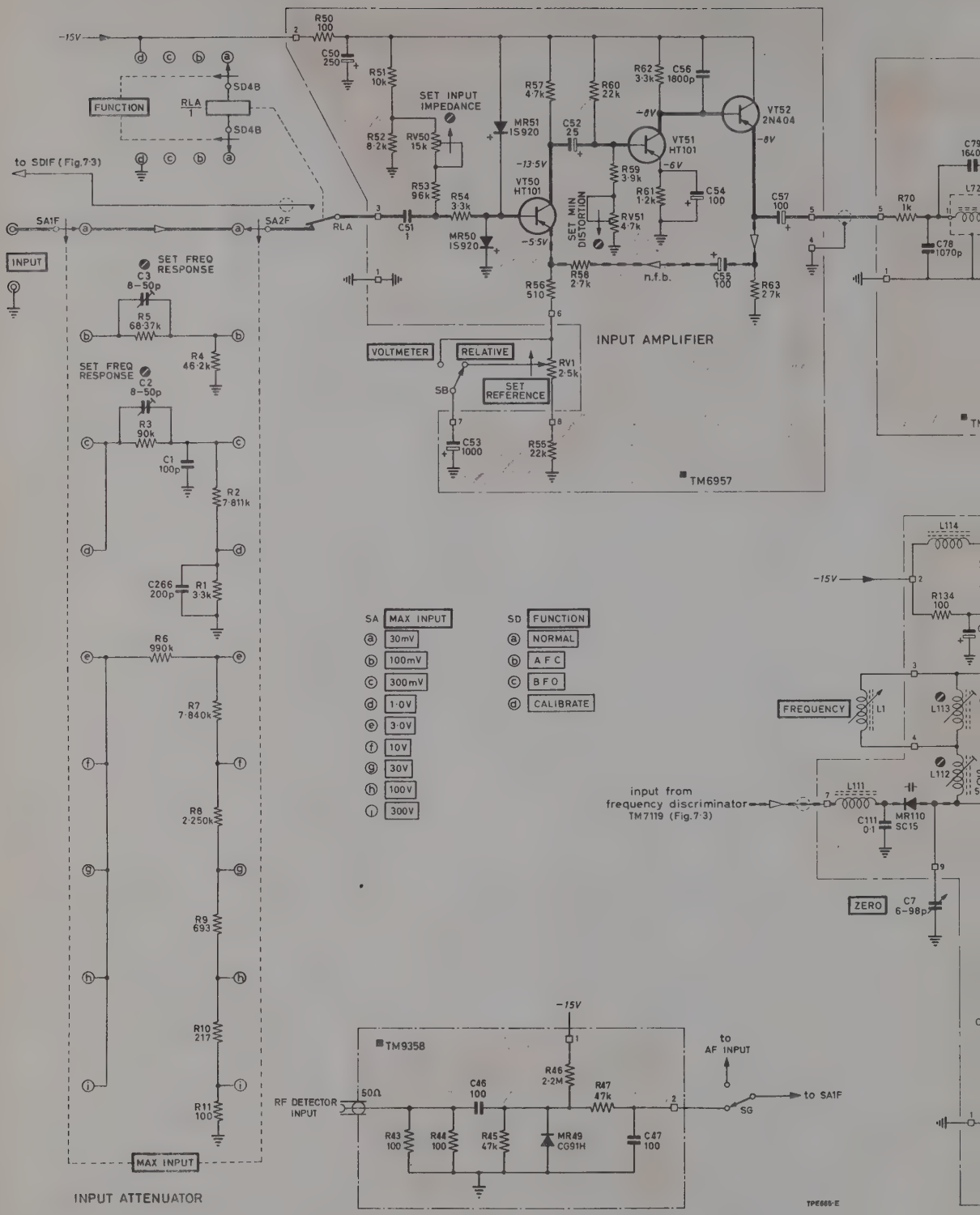


Fig. 7.1 Power supply


INPUT ATTENUATOR
INPUT AMPLIFIER
TM6957
TM9358
SA MAX INPUT
a 30mV
b 100mV
c 300mV
d 1·0V
e 3·0V
f 10V
g 30V
h 100V
i 300V
SD FUNCTION
a NORMAL
b A F C
c B F O
d CALIBRATE
FUNCTION
RLA
SD4B
SA1F
SA2F
INPUT
SET FREQ RESPONSE
SET INPUT IMPEDANCE
SET MIN DISTORTION
SET REFERENCE
VOLTMETER
RELATIVE
MAX INPUT
FREQUENCY
ZERO
n.f.b.
to SDIF (Fig.7·3)
input from frequency discriminator TM7119 (Fig.7·3)
RF DETECTOR INPUT
to AF INPUT
to SA1F
SG
TPE669-E

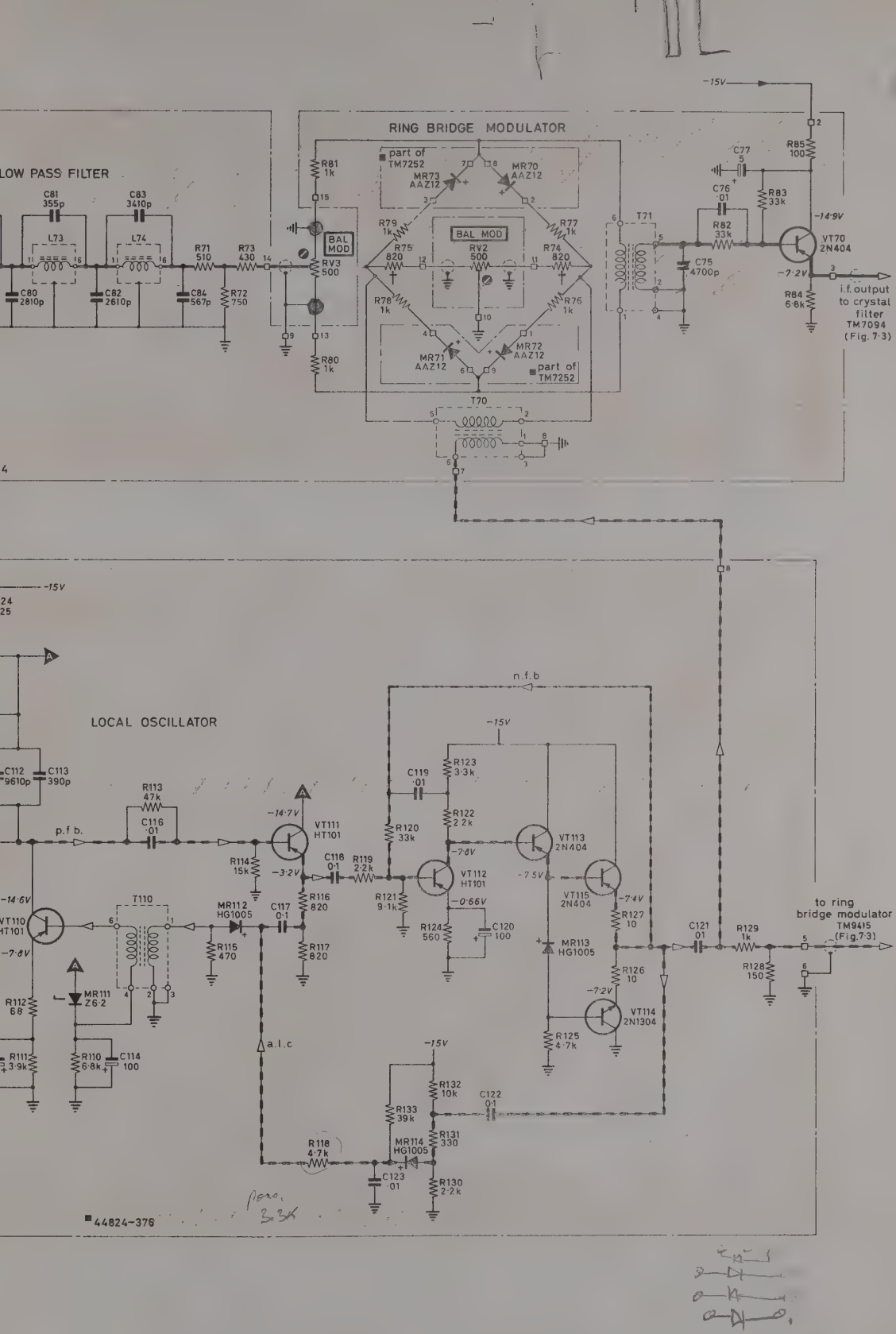
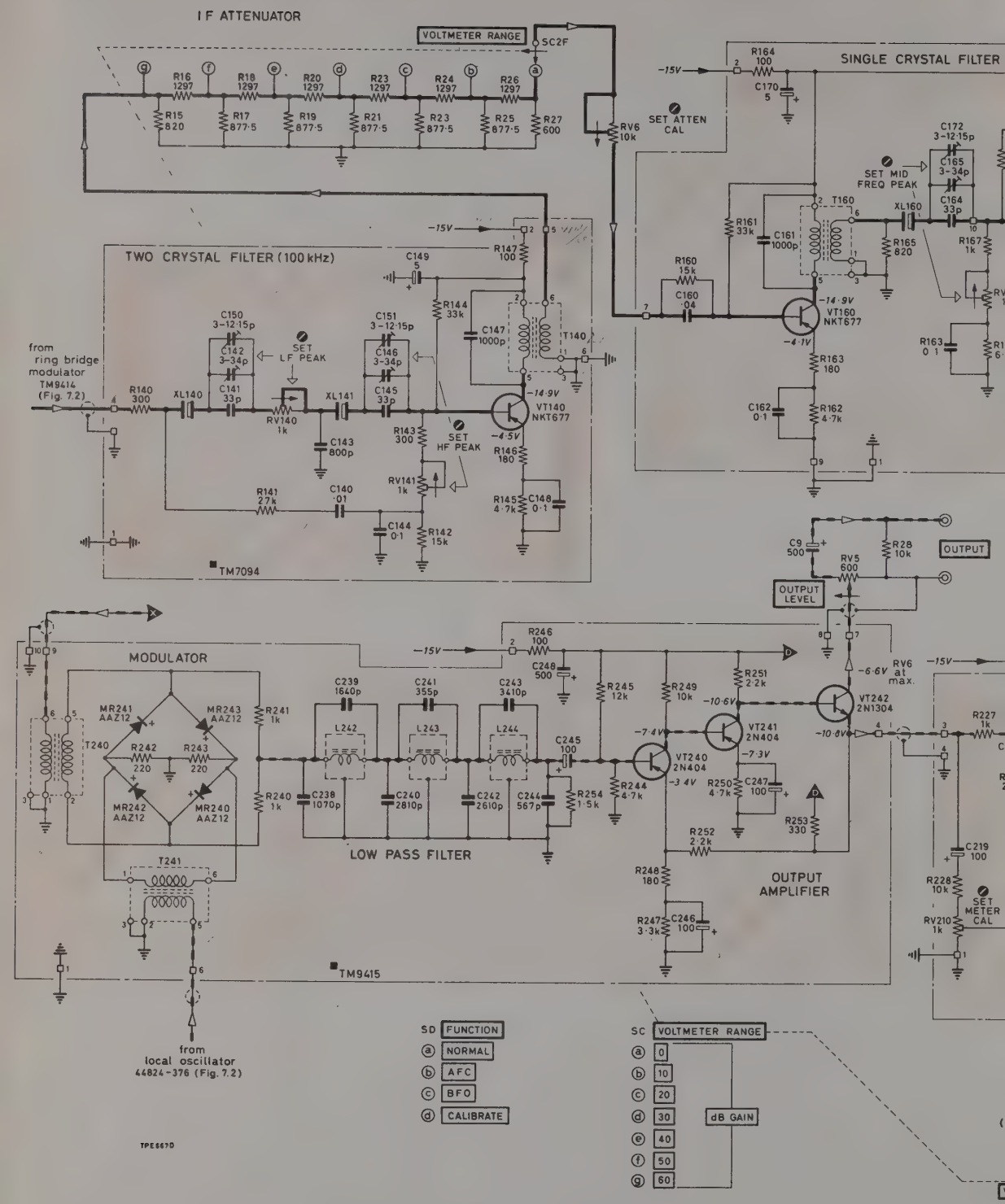


Fig. 7.2 Input stages


I F ATTENUATOR
VOLTMETER RANGE
SC2F
R16 1297
R18 1297
R20 1297
R23 1297
R24 1297
R26 1297
R15 820
R17 877·5
R19 877·5
R21 877·5
R23 877·5
R25 877·5
R27 600
RV6 10k
SET ATTEN CAL
SINGLE CRYSTAL FILTER
-15V
R164 100
C170 5
C172 3-12·15p
C165 3-34p
SET MID FREQ PEAK
C164 33p
XL160
T160
R161 33k
C161 1000p
R165 820
R167 1k
R160 15k
C160 ·04
-14·9V
VT160 NKT677
-4·1V
R163 180
C162 0·1
R162 4·7k
R163 0·1
TWO CRYSTAL FILTER (100 kHz)
C149 5
R147 100
R144 33k
C147 1000p
T140
C150 3-12·15p
C142 3-34p
C141 33p
SET LF PEAK
C151 3-12·15p
C146 3-34p
C145 33p
from ring bridge modulator TM9414 (Fig. 7.2)
R140 300
XL140
RV140 1k
XL141
C143 800p
R143 300
SET HF PEAK
-14·9V
VT140 NKT677
-4·5V
R146 180
RV141 1k
R141 27k
C140 ·01
R145 4·7k
C148 0·1
C144 0·1
R142 15k
TM7094
C9 500
R28 10k
OUTPUT
RV5 600
OUTPUT LEVEL
MODULATOR
R246 100
C248 500
R245 12k
R249 10k
R251 2·2k
-6·6V at max.
RV6
VT242 2N1304
-10·6V
VT241 2N404
-7·4V
-7·3V
VT240 2N404
-3·4V
R250 4·7k
C247 100
R253 330
R252 2·2k
R248 180
R247 3·3k
C246 100
OUTPUT AMPLIFIER
R227 1k
C219 100
R228 10k
SET METER CAL
RV210 1k
MR241 AAZ12
MR243 AAZ12
MR242 AAZ12
MR240 AAZ12
T240
R242 220
R243 220
R241 1k
R240 1k
C239 1640p
C241 355p
C243 3410p
L242
L243
L244
C245 100
C238 1070p
C240 2810p
C242 2610p
C244 567p
R254 1·5k
R244 4·7k
LOW PASS FILTER
T241
TM9415
from local oscillator 44824-376 (Fig. 7.2)
SD FUNCTION
a NORMAL
b AFC
c BFO
d CALIBRATE
SC VOLTMETER RANGE
a 0
b 10
c 20
d 30
e 40
f 50
g 60
dB GAIN
TPE6670

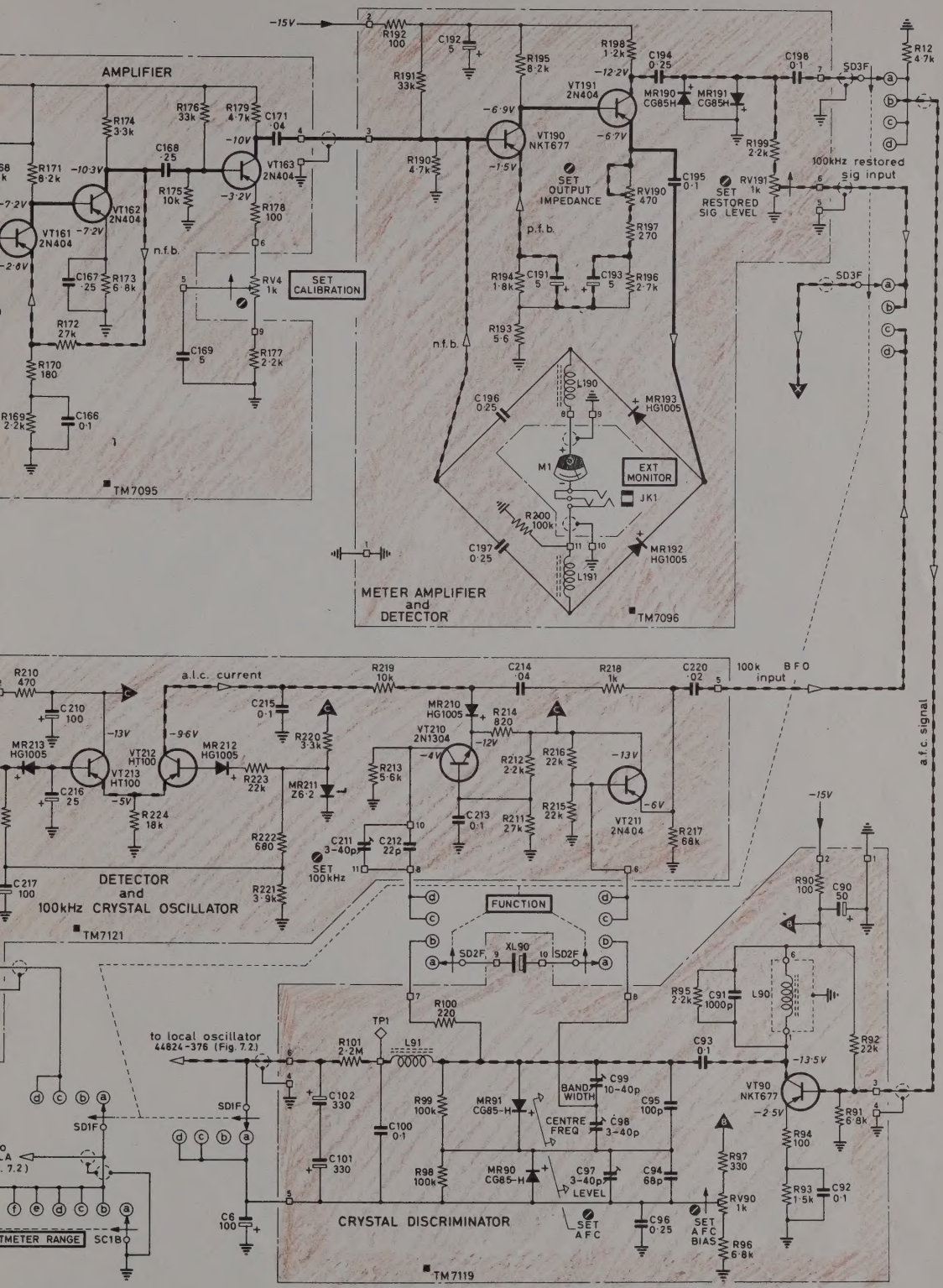


Fig. 7.3 Power supply

TF 2330A

MARCONI INSTRUMENTS LIMITED
ST. ALBANS, HERTS., ENGLAND

SERVICE DIVISION	HEDLEY ROAD, ST. ALBANS, HERTS. Telephone: St. Albans 50731 (Ansafone)
HOME and EXPORT SALES OFFICES	LONGACRES, ST. ALBANS, HERTS. Telephone: St. Albans 59292 Telegrams: Measurtest, St. Albans Telex: 23350
U.S.A.	MARCONI INSTRUMENTS DIVISION OF ENGLISH ELECTRIC CORP., 111 CEDAR LANE, ENGLEWOOD, NEW JERSEY 07631 Telephone: 201 567-0607
BUNDESREPUBLIC DEUTSCHLAND	MARCONI MESSTECHNIK G.M.B.H. P.O. BOX NO. 210330 JOERGSTRASSE 74 8000 MUNICH 21 Telephones: 58.32.97; 58.42.05; 58.61.56 Telex: 524642
FRANCE	MARCONI INSTRUMENTS SUCCURSALE DE FRANCE 32 AVENUE DES ECOLES 91 SAVIGNY SUR ORGE Telephone: 921.69.93

WORLD-WIDE REPRESENTATION

www.manualsplus.com
1003822

Printed in England by The Compfield Press, St. Albans